Metal Progress

OCTOBER, 1955



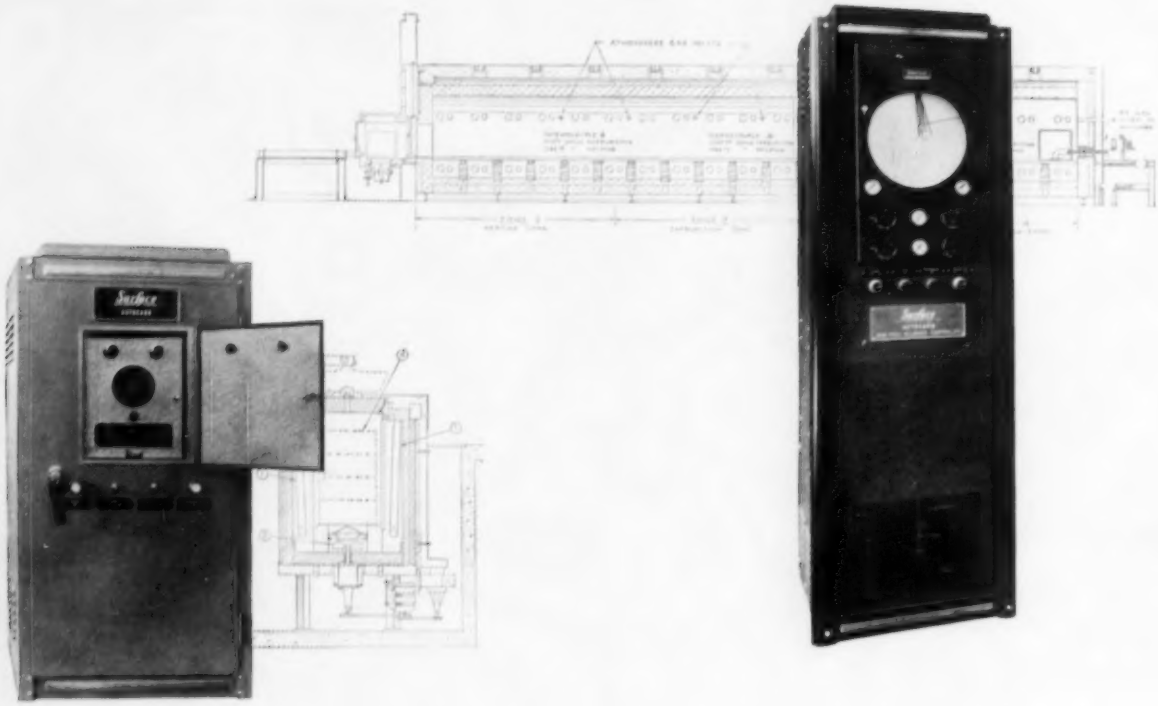




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Philadelphia-
October 17-21, 1955

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write for Bulletin H55-13

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Metal Progress

Volume 68, No. 4

October . . 1955

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Cover by FLOYD E. CRAIG

National Metal Congress and Exposition

Invitation 69

Consolidated Program 70

Chronological listing of events scheduled for the week starting Oct. 15.

Technical Programs 72

Titles of papers, names of speakers and lecturers for the technical sessions sponsored by A.S.M., Institute of Metals Division of A.I.M.E., American Welding Society, Metals Division of Special Libraries Association, Industrial Heating Equipment Association, U.S. Atomic Energy Commission, and Office of Ordnance Research, U.S. Army.

National Metal Exposition 82

Exhibitors, booth numbers and descriptions of products in ten subject categories.

Engineering Articles

One Hundred Years of Metallurgy at Yale 105

The first American professorship in metallurgy was established just a century ago during the formative stages of Sheffield Scientific School. George J. Brush was the first incumbent. Fifty years ago the Hammond Metallurgical Laboratory was built, and 48 years ago Champion Herbert Mathewson joined the faculty. (A 2, A 3*)

Protecting Molybdenum From Oxidation, by Alvin J. Herzig and James R. Blanchard 109

Cladding, electroplating, metal spraying and ceramic coating offer promise for protecting molybdenum under various conditions and services. (L 17, L 23, L 24, L 27, Mo)

Rolled Metal Powder Sheet, by Lincoln T. Work, John D. Shaw, and Walter V. Knopp 115

Good quality copper strip is being produced from roll-bonded copper powder. The powder is obtained by leaching low-grade copper-bearing scrap which cannot be remelted into ingot of good quality. (H 10, H 14, Cu)

Continuous Casting, by J. S. Smart, Jr. 117

The experience gained with aluminum and copper alloys has helped develop continuous casting of steel to a practical production method. (C 5, D 9)

Table of Contents Continued on P. 3

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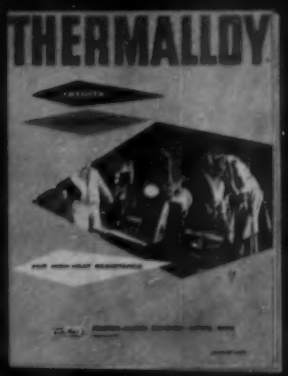
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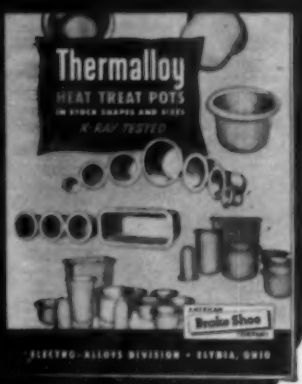
Centrifugal
Castings Bulletin



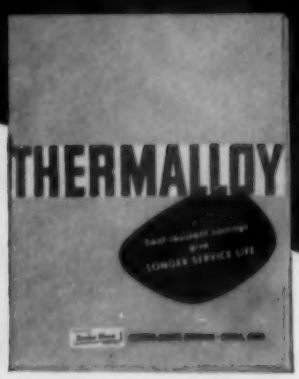
Muffles & Retorts
Bulletin T-239



Heat Treat Trays & Fixtures
Bulletin T-227



Heat Treat Pots
Bulletin T-234



General Thermalloy
Catalog T-225



Conveyor Belt
Bulletin T-241

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Ductile Iron-Aluminum Alloys, by Eric R. Morgan and Victor F. Zackay 126

Ductile iron-aluminum alloys with oxidation resistance and high-temperature strength equivalent to conventional stainless steels can be produced by vacuum melting. (Q 23, R 2, D 8, SG-h)

Monel, 1905 to 1955, by W. A. Mudge 132

Monel nickel-copper alloy was first produced 50 years ago and its continued development parallels the progress in metals engineering. (A 2, Ni)

Book Review

Reference and Bibliography on Nickel Steels and Irons, by David S. Wood 129

"Nickel in Iron and Steel" by A. M. Hall is the 13th in the important Alloys of Iron Research Monograph Series sponsored by the Engineering Foundation.

Atomic Age

Genetic Effects of Atom Bombs 130

Radioactivities from natural sources are greater than the fall-out from atomic bomb tests to date, but the genetic effects of a nuclear war might be catastrophic.

Correspondence

Measuring Case Depth, by H. C. Thomas; L. E. Webb 136

A method used in a British plant, and a brief outline of an "S.A.E. Recommended Practice" for shop control of case depth.

Cast Bolts for Pipe Joints, by A. L. Boegehold; C. K. Donoho 138

Straightens out the patent background for the method of making malleable iron in a short time described in the May issue.

Data Sheet

Standard Stainless Steels, Wrought and Cast 104-B

A.I.S.I. designations for the wrought steels brought up to date as of April 1955, plus latest (1954) Alloy Casting Institute designations for the cast steels.

Digests of ASM Convention Papers

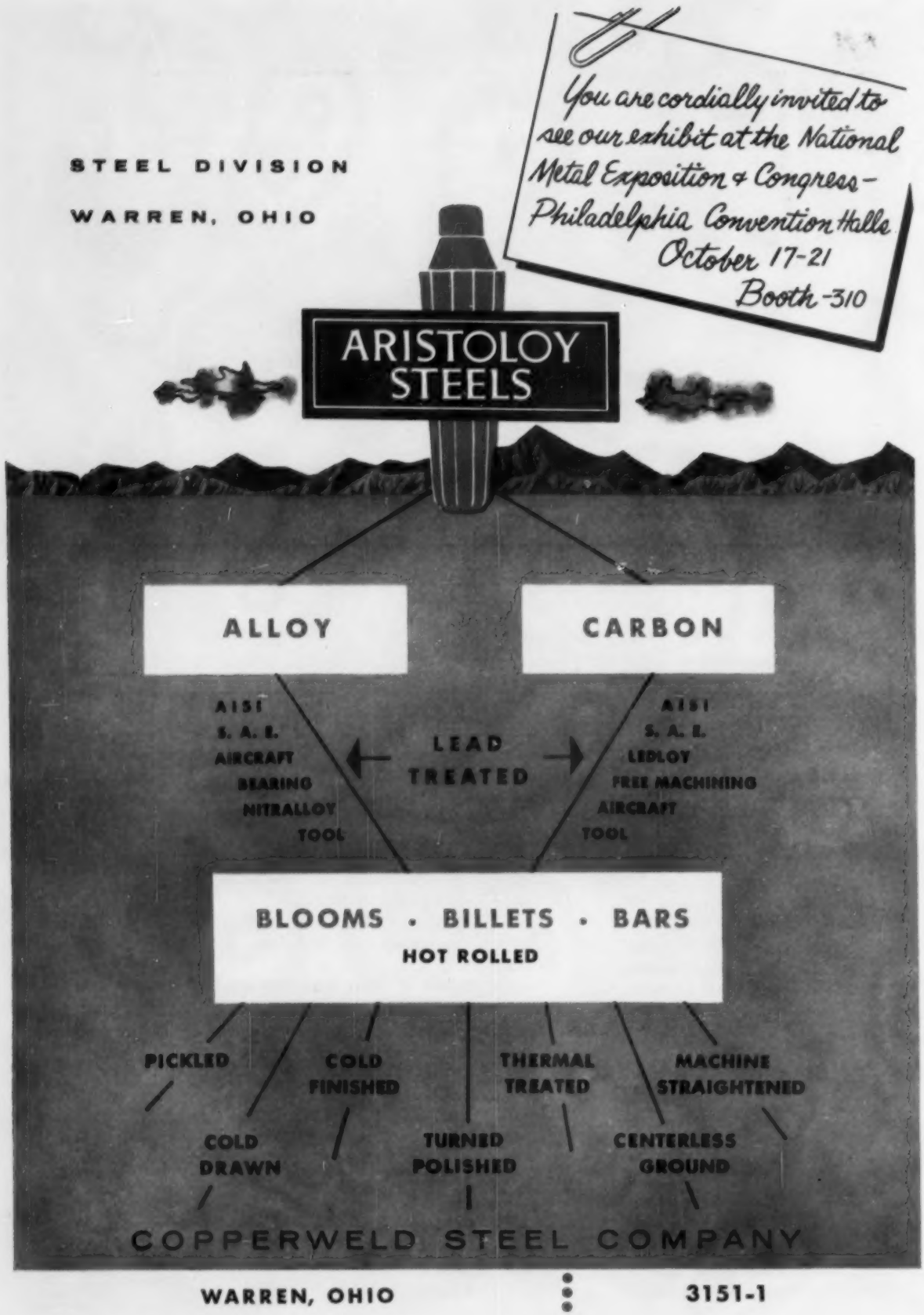
Strengthening Stainless by Cold Work 163
Heat Treatability of a Titanium Alloy 163
Torsional Properties of Steel 164
Hydrogen Absorption by Titanium 166
Effect on Surfaces of Metal Removal 168
Fatigue and Anisotropy in Copper 172
Deformation of Beryllium 176
Low-Temperature Deformation of Mg 178
Rolling Textures in Tantalum 180
Graphitization of Steel 183
High-Nitrogen Stainless Steel 184
Effect of Tempering Temperature on Martensitic Stainless 188
Metallography of Titanium 192
Static Fatigue of High-Strength Steel 196
Deformation Rate Sensitivity of Stainless 198
Shock Loading of Mild Steel 204
Corrosion Resistance of High-Alloy Stainless 206
Creep Resistant Zirconium Alloys 210
Diffusion of Carbon in Titanium 214
Decomposition of Ti-V Alloys 216
Solidification of Aluminum 218
Zirconium-Chromium Alloys 220
Effect of Silicon in High-Strength Steel 222

Digests of Other Important Articles

Fatigue Tests on British Wrought Steel—Part II 224
Problems of the Thermal Barrier 228
Energy Criteria of Fracture 234
Turning Country Rock Into Iron Ore 238
Impact Tensile Test Clarifies Hot Working Properties 242
Notch Effects on High-Temperature Alloys 246

Departments

As I Was Saying, by Bill Eisenman 5
Engineering Digests of New Products 9
Manufacturers' Literature 21
Personals 140
Advertisers' Index 292


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As I was saying...



IT IS A LONG leap from the No. 1 Metal Show and Convention in 1919 to the 37th which opens in Philadelphia on Oct. 17. The No. 1 Show was held in Chicago at the Seventh Regiment Armory and occupied all of 10,000 sq. ft. Arthur Henry, one of the prime movers in organizing the A.S.M. and one of the five founder members, was the "daddy" of the first Metal Show.

The year before, Arthur had gone to Milwaukee for one of the early foundry shows (AFS). He returned to Chicago with the idea that what this young upstart of a Society should have was an exhibit of heat treating materials and appliances. So one of the first activities to which I had to devote my attention was the planning for the Show and the preparation of the program.

The September opening date soon rolled around and the great experiment turned out to be a great success. I like to quote the statement which appeared in the *Iron Age* immediately following the convention, in which Ed Cone reported that: "The surprise of the week was the convention and exposition of the young steel treating society which gave every indication that the Society was set up to go places and do things."

I recall we presented 78 papers and had approximately the same number of exhibitors (as against today's 450). Quite a number of them have been in the Show continuously since the first one. It is interesting to note that they have grown and prospered in the same manner as the A.S.M.

As I look back over the conventions and expositions between No. 1 and No. 37, the one that stands out in my mind as a real experience is No. 2, which was held in Philadelphia in 1920. There was great enthusiasm among members in the East, and the attendance zoomed. There were many more exhibitors and many more papers than there had been in Chicago the previous year. The exposition was held in the Commercial Museum, and the buildings (with the exception of the Auditorium) looked much the same as they do today. When you realize that these buildings were a part of the centennial of '76, you will have to admit that "in them there days" they built well.

We almost lost the opportunity of a return visit to Philadelphia when the 1920 booth contractor and decorator (a Philadelphia citizen) dug up most of the cedar trees on the grounds of the Museum and rented them to the exhibitors for "a nominal fee." But by changing contractors we were able to return in later years.

The 1955 Congress and Exposition makes the sixth time we have been in Philadelphia. It is a wonderful show town for the A.S.M. It has splendid facilities, expertly managed.

The attendance is usually predominantly from the East, but since the Exposition comes to Philadelphia only once every three years, practically all the manufacturers have new and improved products to show. There is also a large growth of new faces in the industry to hear the papers and new spectators to note the improvements.

So here is my wager: That the Philadelphia Metal Congress and Exposition of 1955 will attain a high-letter mark, not only in the caliber of the program but the number of exhibitors and the audience reached.

So I am looking forward to seeing you in Philadelphia and I hope you will not disappoint me.

Cordially yours,

Bill

W. H. EISENMAN, *Secretary*
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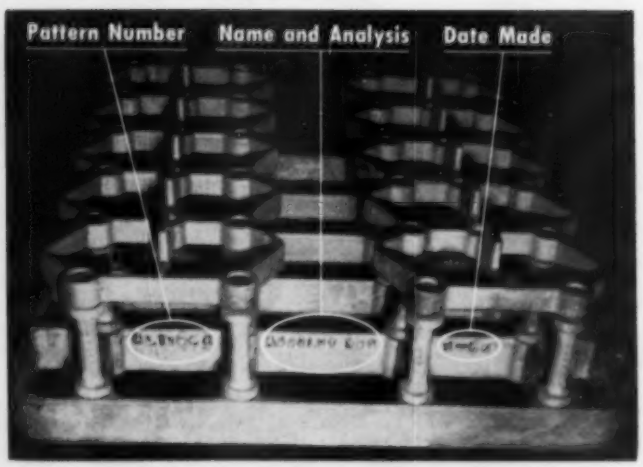
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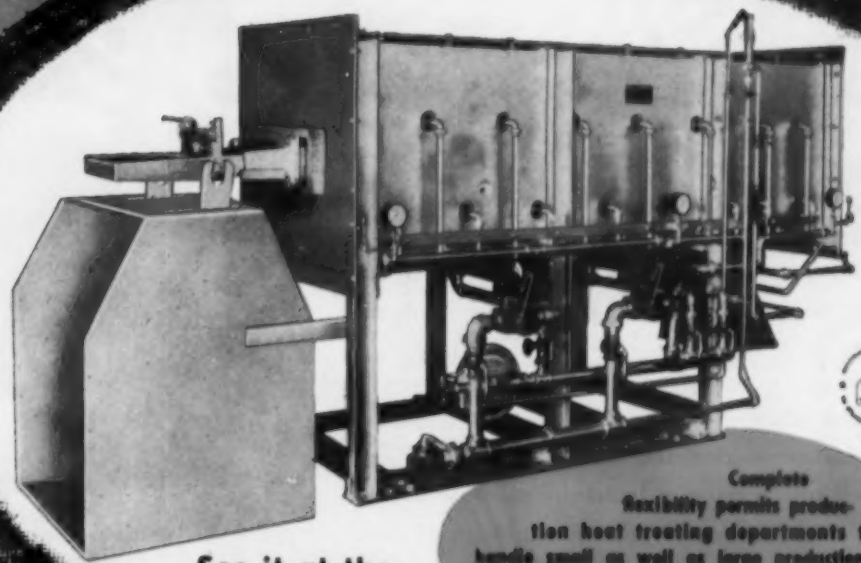
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Engineering Digest of New Products . . .

Gas Carburizer

New heat-treating equipment, including a large radiant tube pit-type gas carburizing furnace has been installed at the Pittsburgh Gear Co. The equipment is designed to provide advanced techniques in deep case carburizing and hardening in controlled atmosphere. The new installation includes a carburizing and hardening furnace, a double propeller

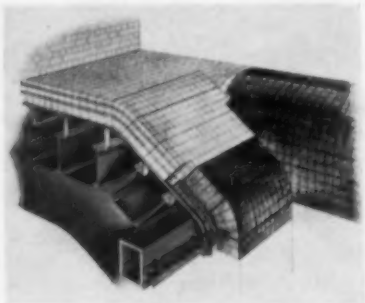


agitated 6000 gal. direct cooled quench tank and an 8000 gal. reserve storage, provided with heat exchangers and coolers to maintain and control oil quench temperatures, as well as a dual-heat 1400° F. draw furnace. The system will handle parts to 6 ft. in diameter and 6 ft. long, and 8500 lb. in weight. It was designed to produce up to 25 tons of deep case carburizing per month.

For further information circle No. 1072 on literature request card, p. 32-B

Furnace Arch

A new interchangeable-type arch adaptable to openhearth or reheating furnaces has been announced by Laclede-Christy Div. Service of 850

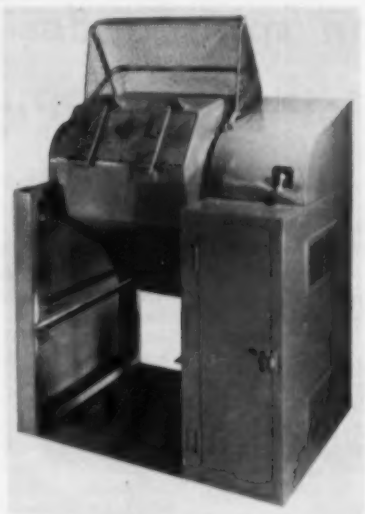


to 1000 heats is reported. Basic tile or clay tile may be hung on the supporting structure and more or less basic tile may be used subsequently on this same structure as may be indicated by the results obtained in actual service.

For further information circle No. 1073 on literature request card, p. 32-B

Finishing Barrel

Lord Chemical Corp. has announced a heavy-duty barrel for precision finishing of stamped, forged, machined or cast parts. It is powered by a 1-hp. motor and is built to tumble heavy parts and to operate for long runs. Inside dimensions of the octagonal compartments are 19 in. across from flat to flat by 9½ in. long; each compartment has a volume of 1.6 cu. ft. and will hold approximately 250 lb. Inside dimensions of



door openings are 8 by 7 in. The barrel is 48 in. high and occupies 31 by 38½ in. of floor space.

For further information circle No. 1074 on literature request card, p. 32-B

Stud Welding Machine

A new fully automatic stud welding machine will be introduced by Graham Manufacturing Corp. at the National Metal Exposition in Philadelphia, October 17 to 21. This unit will be fixtured for welding studs to strip stock fed continuously from a coil. Stud feed to the gun is automatic. Studs can be welded at the rate of approximately 80 per min. while power consumption averages 1½ kva. This unit can be furnished



with a revolving index table to permit stud welding of various individual parts or assemblies. A pedal is supplied to permit single stroke operation of the gun.

For further information circle No. 1075 on literature request card, p. 32-B

Surface Roughness

Equipment for automatic surface-roughness inspection has been announced by Micrometrical Manufacturing Co. This equipment sorts parts in accordance with the microinch roughness measured along an o.d. or flat surface, including tapers and parts with grooves or shoulders. The work-pieces go from a feed chute onto a conveyor belt which moves them beneath a Profilometer tracer. As the parts leave the tracer, they are automatically directed into an "accept" or "reject" discharge chute in accordance with their roughness. Equipment can be furnished to accept work within a selected range of roughness, rejecting parts that are either too rough or too smooth.

For further information circle No. 1076 on literature request card, p. 32-B

Cleaning Compound

A compound for cold cleaning metal parts before inspection, storing or further processing has been announced by International Chemical Co. This cold cleaner is intended for use diluted with water in pressure spray power washing machines. A concentrated liquid mixture of detergents,

ONLY CHRYSLER MAKES OILITE®



one-half million spins under tension and— OILITE bearings show no appreciable wear

Here's a fishing reel that is subjected to laboratory tests far more drastic than it receives from anglers —*and the self-lubricating OILITE bearings take it in stride.* Here's what the spinning reel manufacturer reports:

"Last summer we had one stock reel tested under tension (up to and including four pounds) at varying speeds. This reel had your bearings, of course.

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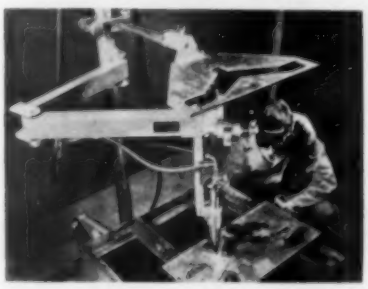


wetting agents, high solvency power naphthas and solvents, rust inhibitors and emulsifiers make up the compound. Temporary rust prevention is provided by forming an inhibitive film over cleaned parts.

For further information circle No. 1077 on literature request card, p. 32-B

Flame Cutting

A new flame-cutting machine featuring a permanent magnetic roller has been announced by Air Reduction Sales Co. The No. 42 Camograph cuts any shape up to a 42-in. circle and



straight lines to 92 in. The permanently magnetized tracing roller follows a metal template. The motor drive shaft is equipped with a simple worm-gear drive; there are no couplings, pulleys or belts. The Camograph is portable.

For further information circle No. 1078 on literature request card, p. 32-B

Torsion Testing

A torsion testing machine in which torsion measurements are made electrically by means of an SR-4 resistance wire strain gage device has been announced by Baldwin-Lima-Hamilton Corp. The new machine is of 60,000 in.-lb. capacity and will be used in studying torsional strength of solid and hollow shafts, structural shapes,

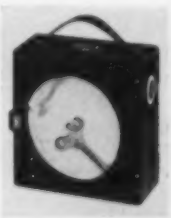


and certain aircraft structures. It accommodates test specimens having a maximum length of 6 ft. between chucks. It has a reversible drive with an infinitely variable speed range of 5 to 200 deg. per minute. The torque pickup is a low deflection steel shaft on which SR-4 resistance wire strain gages are bonded so as to cancel bending and thrust strains. Output of the torque pickup is fed by a single cable into an electronic amplifier and indicating instrument which provides three ranges on a 24-in. diameter dial that reads directly in inch-pounds for twists in both directions. Lowest range is 0 to 6000 in.-lb.

For further information circle No. 1079 on literature request card, p. 32-B

Temperature Recorder

A miniature recorder for use in cold storage rooms and refrigerator cabinets, has been announced by the Weston Electrical Instrument Corp. This recorder is self - contained and unaffected by atmospheric pressures and constructed to resist the service encountered in transportation.



The pen operates directly off the sensing element without multiplying levers. The case is made of light weight die-cast aluminum to provide maximum crush resistance, and has no protruding parts. It is furnished for a range of operating temperatures, from −40 to +140° F., in 50 and 100° included spans.

For further information circle No. 1080 on literature request card, p. 32-B

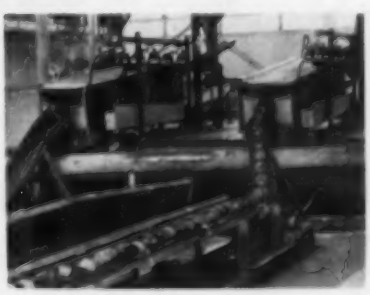
Hard Facing Electrode

A new hard facing electrode for use where high corrosion and high abrasion at elevated temperatures are encountered, has been announced by Mir-O-Col Alloy Co. Mir-O-Col No. 11 is a cast alloy of the nonferrous type, containing cobalt, chromium and tungsten, with a hardness of Rockwell C 50 to 52 as deposited. Due to its high hardness, it is recommended where only moderate impact is encountered.

For further information circle No. 1081 on literature request card, p. 32-B

Induction Heating

Mullins Mfg. Corp. has announced a new method for low-frequency induction heating. The heating medium





Build better profits from higher grade, controlled castings which have the uniform characteristics you get by degassing your melts in the Kinney Mobile Vacuum Degasser. Here's how this unit helps you do it:

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- Eliminates chemical and gas flushing
- Lets you use lower grade metals
- Eliminates costly impregnation processes
- Requires no skilled operator

The Kinney Mobile Vacuum Degasser is a dependable, trouble-free unit of rugged design, built to stand the test of modern foundry operation. The vacuum chamber is generously proportioned and designed for easy melt control and observation. Rapid pump down to low pressures is achieved by an efficient Kinney Model KDH-130 vacuum pump . . . gas ballasting, a primary requirement for efficient operation, is featured.

Put your foundry on the road to better castings and better profits . . . write today for Bulletin 402. Kinney Manufacturing Division, The New York Air Brake Company, 3584 Washington St., Boston 30, Massachusetts.

Kinney

ELIMINATE EXPENSIVE FINISHING!

FABRICATE *Your* products from ALUMINUM PRE-ENAMELED COILS

Available in widths up to 36"

You can cut production time and increase output when you fabricate from pre-painted aluminum. Colorweld Coil, roller-enameled aluminum, retains its original color perfection throughout most fabrication stresses and production operations. Colorweld's baked-on enamel finish permits bending, forming, slitting, stamping and most drawing operations without scratching or peeling. By a special process, including careful Alodizing, the colors literally are welded to the metal for a lasting finish.



Colorweld Coil is available in widths ranging from ½" to 36", in thicknesses from .016" to .051". It can be coated in a variety of standard colors, enameled on one side or two, using the same or a different color.

To add sales appeal to your products at substantially reduced production costs, fabricate your products from Colorweld Coil. We shall be glad to send you additional information, without obligation. Write to us today.

Colorweld COIL

SOUTHERN STATES IRON ROOFING COMPANY
GENERAL SALES OFFICES, SAVANNAH, GEORGIA



PANGBORN
HYDRO-FINISH

For easier handling, for added efficiency . . . look to the new Pangborn Hydro-Finish! Hydro-Finish cleans and finishes molds and dies in minutes, holds fine tolerances. And now it offers many new advantages! Pangborn has done away with the pump; air jet sluriators now keep the abrasive in suspension. This means a lower investment and fewer moving parts. Optional equipment includes a loading stand that simplifies handling, washing and inhibitor application. The cabinet has been redesigned for more efficient operation. These and other advantages make the Pangborn Hydro-Finish ideal for precision cleaning and finishing!

For further details on Hydro-Finish, send for Bulletin 1403 now! Write PANGBORN CORP., 1800 Pangborn Blvd., Hagerstown, Maryland. *Manufacturers of Blast Cleaning and Dust Control Equipment.*

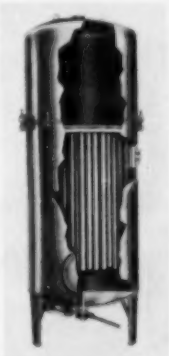
Pangborn
BLAST CLEANS CHEAPER

is an induction coil using 60-cycle, single phase, alternating current. Coil capacity ranges up to 2,000 lb. of processed steel per hour with an energy consumption of 1 kwh. per 14 lb. of metal heated to a temperature of 1350° F. A given coil has been used to heat 4-in. diameter billets, ¾-in. diameter rivets, or 1-in. diameter bolts. Heaters are available through Loftus Engineering Corp.

For further information circle No. 1082 on literature request card, p. 32-B

Precoat Filter

A new precoat filter with a built in backwashing feature which eliminates manual cleaning has been announced by Houdaille-Hershey. Unit is to be mounted on a central coolant system tank. A circular steel plate divides filter body into two sections. Above is a clean coolant dome; below, 199 perforated filter tubes suspended vertically. Screens are coated with diatomaceous earth. In normal operation, only one precoat is needed daily. During the filtration cycle, all solid particles are removed and held on the coated screens as coolant passes upward through tubes. To reach the outlet at top of filter, coolant must pass through dome section. Constant pressure keeps the dome filled with clean coolant. When contamination on tube surfaces becomes thick enough to impede passage of coolant, the pump is stopped. This reverses flow, sending a backwash of clean coolant from dome down through the tubes.



For further information circle No. 1083 on literature request card, p. 32-B

Roll Formed Tube

Acme Tube Corp. has announced a new type of tube called tight-butted seam tube which features a pressure butt or closure on the longitudinal seam of the tube. The pressure butt is accomplished in the forming process, by directing the metal stresses to counteract each other and close the seam.

For further information circle No. 1084 on literature request card, p. 32-B

Chromate Coating

The Chemical Corp. has announced a new aluminum sealer which produces a chromate film on aluminum that provides corrosion protection

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P AND A serves you the best in brass

With Plume and Atwood's special P°A brass, you can improve your product and save money, too. It's made by a special process to give it a finer grain, a harder surface and a brighter lustre that means a better product with added customer appeal. Its superior quality costs no more and can save you up to 50% on finishing costs. Send us samples of your present brass parts. Our engineering staff is at your service.

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THE PLUME & ATWOOD MANUFACTURING COMPANY

THOMASTON CONNECTICUT

NEW YORK OFFICE 220 BROADWAY

"SERV-RITE"
THERMOCOUPLE
HEAD



the head that's ahead in every way . . .

This new "Serv-Rite" thermocouple head is actually small enough to be held comfortably in the palm of your hand. But size is only one of the many features that make this thermocouple head really extraordinary. It is loaded with installation and service conveniences that any user of thermocouples will appreciate at once.

The body is of malleable iron, cadmium plated for durability. A new type friction lock assures easy removal or tightening of the cap — a quarter turn does it. An asbestos gasket makes the head dirt- and moisture-proof. With a choice of ½", ¾", or 1" IPS opening for the protecting tube, you can standardize on one style head.

The connector block is of a material especially selected to withstand, without damage, temperatures up to 900° F. in continuous service. Improvements over the conventional type of inserts greatly simplify the making of the lead wire connections. The complete thermocouple element, including connector block, can be easily withdrawn for inspection.

Install a "Serv-Rite" thermocouple head and see for yourself how much better it really is.

Write for complete details

4621

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CLAUD S. GORDON CO.

Manufacturers • Engineers • Distributors

Thermocouples & Accessories • Temperature Control Instruments • Industrial Furnaces & Ovens Metallurgical Testing Machines

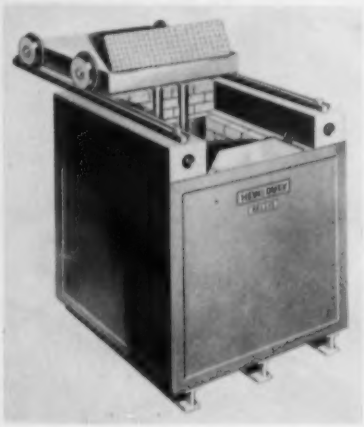
613 West 30th Street, Chicago 16, Illinois
2021 Hamilton Avenue, Cleveland 14, Ohio

and can serve as a paint base. The new sealer replaces anodizing where hardness is not a prime factor. It has salt spray resistance to 600 hr. It is applied in one dip at room temperature. It can be dyed and meets government specification MIL-C-5541.

For further information circle No. 1085 on literature request card, p. 32-B

Salt Baths

Hevi Duty Electric Co. has announced a complete new line of salt bath furnaces of the immersed electrode type, in any size or capacity



with temperatures ranging from 300 to 2400° F. Special features include: immersed electrodes with water-cooled terminals, a patented starting coil of the resistant heater type, a removable ceramic, steel or alloy pot and recessed electrodes.

For further information circle No. 1086 on literature request card, p. 32-B

Metal Sorting

A new sorting instrument for non-destructively testing and sorting mixed or incorrectly processed metal



parts has been announced by J. W. Dice Co. It is used as a hand sorter. A known and acceptable part is inserted in the test coil as a standard in adjusting the Cyclograph. Unknowns then placed in the coil give the same meter reading if they are the same as the standard, a different reading if they are not. The instrument can be used on either ferrous or nonferrous metals of any shape.

For further information circle No. 1087 on literature request card, p. 32-B

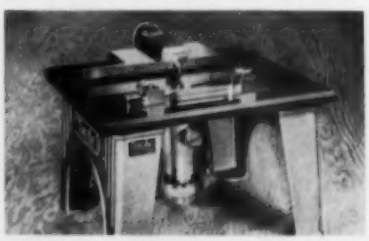
Tube Welding

A high frequency resistance welding technique for tubing has been announced by Rochelle Tool Corp. In the new process effects of high frequency reactance direct the current into the edges of the metal being joined, resulting in high energy concentration. The mill may be changed from one metal to another with only minor adjustments in the welding and forming facilities. Untreated hot and cold rolled steel, stainless, copper, aluminum and brass may be welded.

For further information circle No. 1088 on literature request card, p. 32-B

Test Specimens

Sieburg Industries has announced a new power tool for cutting tensile test specimens to conform to ASTM specifications. Ferrous and nonferrous specimens can be machined in less than 3 min. It is claimed that Tensil-



kut reduces cold working of test specimen edges. The machine is portable and easy to operate.

For further information circle No. 1089 on literature request card, p. 32-B

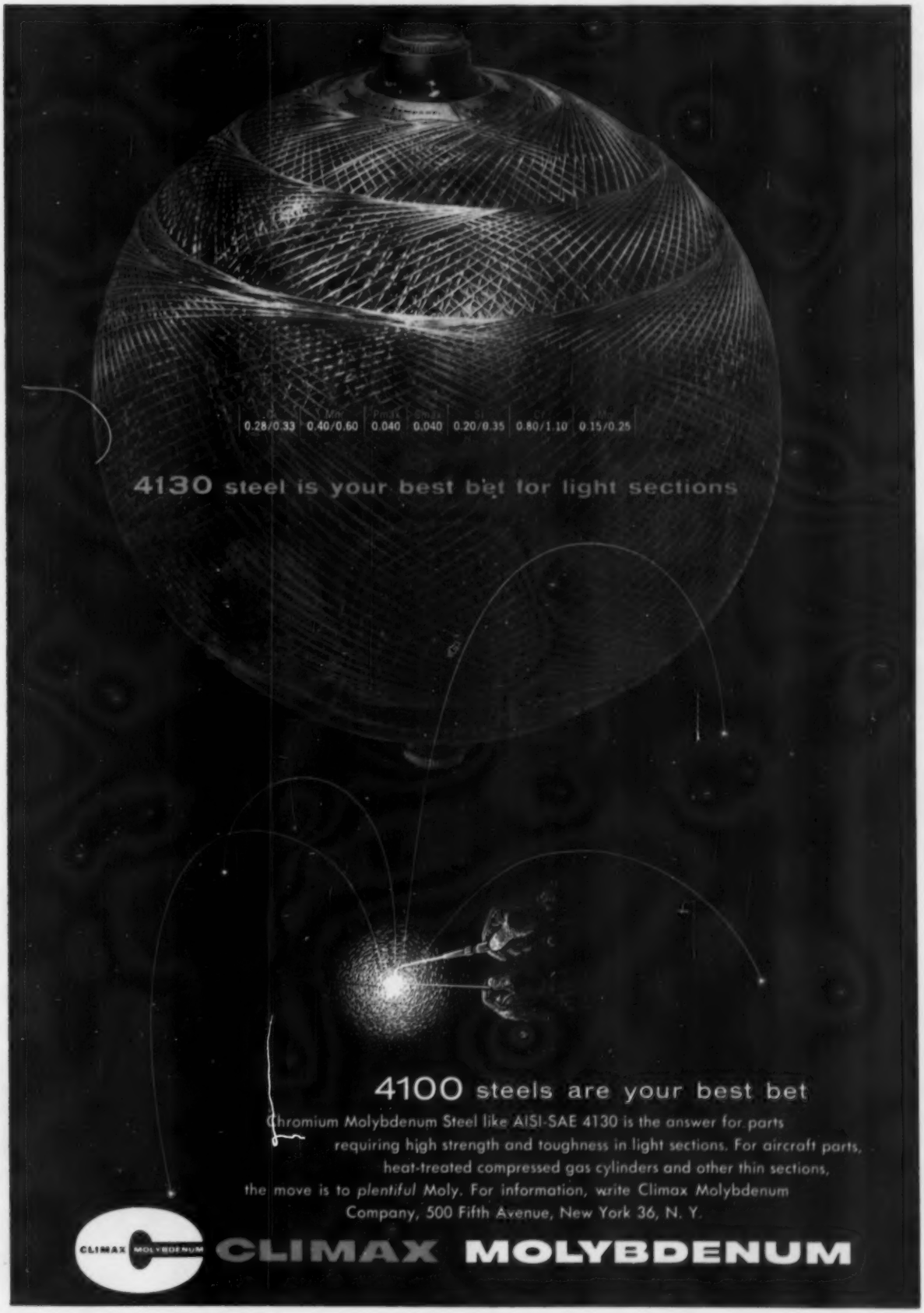
Leaded 52100 Steel

Leaded 52100 round steel bars have been announced by Peterson Steels. A small amount of lead (0.15 to 0.35%) acts as a lubricant, reducing friction between tool face and chip and resulting in an improvement in machinability. Hardenability, tensile strength, ductility and impact strength are unchanged. Leaded 52100 is heat treated the same way as unleaded material.

For further information circle No. 1090 on literature request card, p. 32-B

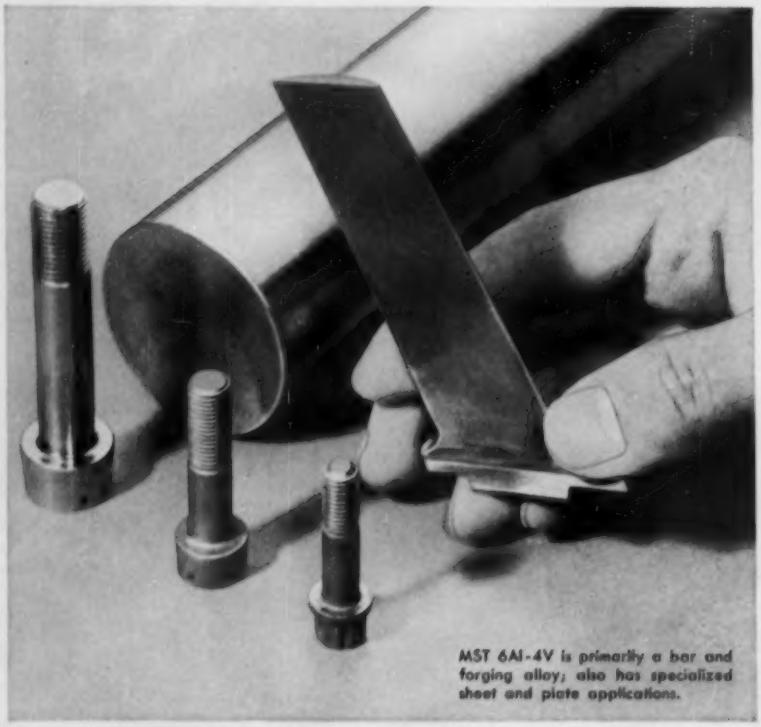
Portable Dew Point Indicator

A new, portable, dew point indicator has been announced by General Electric's Instrument Dept. The indicator determines the moisture content of a gas by measuring the temperature at which the moisture begins to condense. This is done by cooling a


0.28/0.33 0.40/0.60 0.040 0.040 0.20/0.35 0.80/1.10 0.15/0.25
4130 steel is your best bet for light sections
4100 steels are your best bet
Chromium Molybdenum Steel like AISI-SAE 4130 is the answer for parts requiring high strength and toughness in light sections. For aircraft parts, heat-treated compressed gas cylinders and other thin sections, the move is to *plentiful* Moly. For information, write Climax Molybdenum Company, 500 Fifth Avenue, New York 36, N. Y.
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MALLORY·SHARON reports on

TITANIUM



MST 6Al-4V is primarily a bar and forging alloy; also has specialized sheet and plate applications.

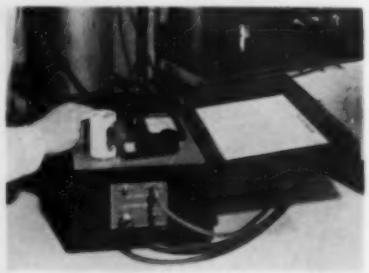
NEW MST ALLOY
"stays put" at high temperatures

● The problem of elevated temperature embrittlement present with many titanium alloys has been overcome with this newest development. MST 6Al-4V (6% aluminum, 4% vanadium, balance titanium) can be used at temperatures up to 750°F with minimum creep or change of properties. It has excellent strength and stability at high temperatures, is relatively insensitive to notches, and can be hot worked over a wide range. It can be readily machined, welded, or heat treated.

Like all Mallory-Sharon alloys, MST 6Al-4V is vacuum double melted, assuring homogeneity and consistent quality. Specify it for consistent, predictable, high temperature performance. A bulletin listing complete data is yours for the asking. Write Mallory-Sharon Titanium Corporation, Dept. F-9, Niles, Ohio.

MALLORY Ti SHARON

mirror surface and observing the temperature at which dew first forms. The indicator gives accurate readings over the range of dew point tempera-



tures from ambient to −100° F. (0.0003% moisture by volume in air). It requires no electrical outlet, operating on a self-contained battery, and can be used to measure different gases in succession.

For further information circle No. 1091 on literature request card, p. 32-B

Plating Barrels

Two new barrel units designed for electroplating small parts and small quantities of larger parts have been announced by Technic, Inc. Model OH-42 is a dual barrel electroplating unit, and Model HP-4 is a portable plating barrel. Both are made of high temperature lucite, so that they can be used in any solution for electroplating precious metals, and will adapt readily to every other type of electroplating. Dual barrel model OH-42 is a complete barrel plating unit of 1 gal. capacity, while the Model HP-4 portable barrel is intended for use by immersion in any existing tank.

For further information circle No. 1092 on literature request card, p. 32-B

Casting Tungsten Carbides

Component Parts Co. has announced a furnace for direct casting to shape of tungsten carbides. Electrically operated and completely automatic, the new furnace can reach 8000° F. and melt 24 lb. of tungsten powder in 3 min. The carbon pickup is made from the graphite crucibles employed. After being loaded with tungsten powder, the three crucibles are raised

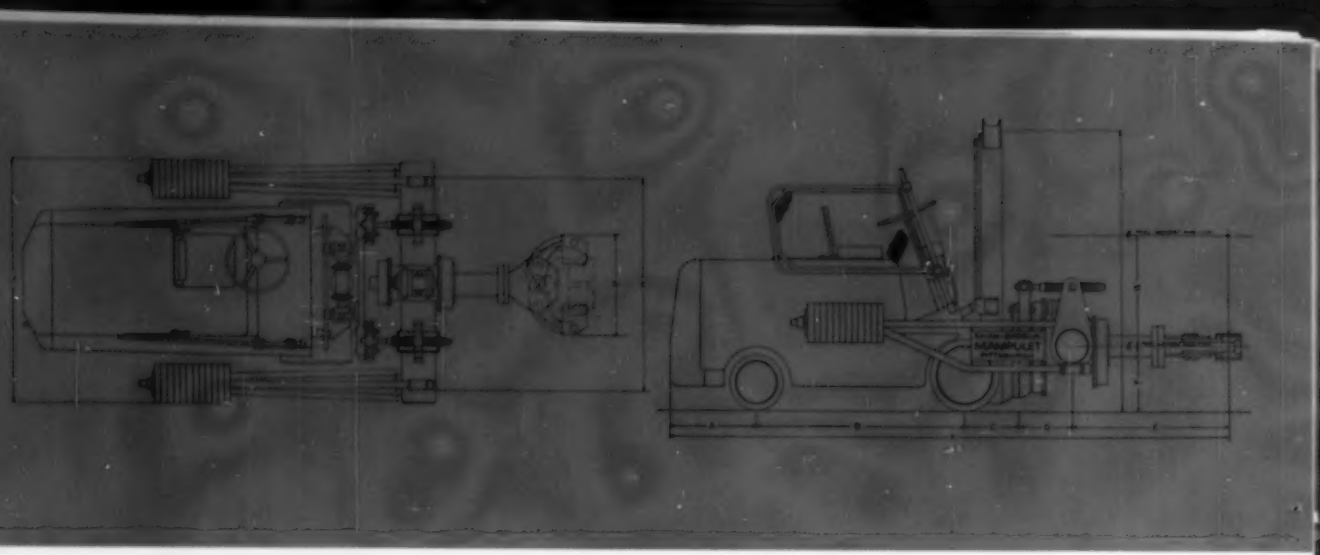


MANIPULET



The Modern, Low-Cost Solution to the High-Cost Problems of:
Hammer Manipulating, Press Loading and Unloading,
Furnace Charging and Drawing, Hot Billet Transportation

SALEM-BROSIUS, INC.



Lift Trucks

Standard, heavy-duty lift trucks of all well known makes can be used as the carrier power-unit for the Manipulet. Manipulets are in use on trucks of a half-dozen makes, operating on electric (battery), gasoline engine, and L. P. gas engine power.

Where gasoline or L. P. gas engine powered trucks are used, some type of automatic transmission on the truck is recommended. Trucks with standard gearing are in use, but an automatic type of transmission permits faster and easier control of floor movement, easier and more accurate spotting of truck and work, and "inching" during forging. Electric or gasoline-electric powered trucks use standard drives. Truck sizes recommended are 6000 lb. heavy-duty trucks for the 500 lb. Manipulet, and 10,000 lb. heavy-duty trucks for the 1500 lb. unit.

Size	500 lb.	1500 lb.
A	2′-3″	2′-3″
B	4′-8″	5′-6″
C	13½″	17″
D	16″	17″
E	5′-0″	4′-1 7⁄16″
F	15½″	1′-8″
G	3′-0″	3′-0″
H	5′-3½″	6′-2″
J	6′-9¾″	6′-11″
K	14′-½″	14′-8 15⁄16″
L	5′-2½″	6′-6″
M	2′-2½″	2′-6″

Tongs Heads

The wide range of shapes, sizes and weights of forgings necessitates designing tongs heads (work-handling heads) to meet specific requirements. Standard heads are available that encompass stock sizes and ranges commonly encountered. Minimum and maximum weight and size ranges, and shapes of rough stock and finished parts must be known, however, before selections of a tongs head can be made. Tongs heads can be supplied for a wide variety of materials-handling operations other than forging.

Salem-Brosius, Inc. procures the necessary lift truck for use with the Manipulet, or it can be supplied by the customer if ordered to Salem-Brosius specifications. The Manipulet is manufactured, installed on the truck, and tested by Salem-Brosius, Inc. at its manufacturing plant in Carnegie, Pa. Installations are not made in the field.

Where forging applications require manipulators of greater load-carrying capacities, the Salem-Brosius Auto-Floor Type Forging Manipulator is available in capacities ranging from 2000 to 20,000 lb.

MANIPULET

SALEM-BROSIUS, INC.

ARCH STREET • CARNEGIE, PENNSYLVANIA

Litho in U.S.A.



Forged-in pockets provide tougher, stronger dies

This 35,000-pound die block, made of Finkl FX-T3 steel, has a forged-in pocket 12″x29″x34″. In addition to the improved physical properties, the pocket forging increases the saving in machining time. There are many ways, such as this, that Finkl engineers can help you when planning die block or forging requirements.

When you next consider hot work tooling, die blocks or forgings, consider Finkl for the best. The quality of Finkl Hot Work Die Steels is the finest available and costs you less in the long run. Finkl die blocks will make a lasting impression with "impressions that last." Our engineers will gladly offer the advantage of their knowledge and our experience. There is no obligation.

DIE BLOCKS
•
HOT WORK STEEL
•
FORGINGS
•
ELECTRIC FURNACE STEELS

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A. Finkl & Sons Co.

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Rx for maintaining hot metal schedules

CRYSTOLON* refractories are engineered and prescribed for more continuous furnace operations, both front and back slagging

You can maintain hot metal schedules for your casting line and avoid costly shutdowns by using Norton CRYSTOLON refractories — *engineered and prescribed* for highest efficiency in handling neutral and acid cupola slags.

For back slagging cupolas the Rx is CRYSTOLON slag hole blocks. For capping the notch and lining the slag chute in front slagging cupolas it's CRYSTOLON bricks and cement.

Wherever you use it, this top-quality silicon carbide refractory material will stand up under temperatures as high as 3050°F without softening, spalling or cracking. Its extreme density assures exceptional resistance to slag penetration and attack — and it lasts 5 to 15 times longer than ordinary fire clay.

In your own foundry

these advantages mean less maintenance time and trouble for your men — and faster, more profitable metal-melting for *you*. CRYSTOLON bricks and blocks are made in sizes and shapes for every foundry requirement. See your Norton Representative for further facts. Or write to NORTON COMPANY, Refractories Division, 331 New Bond St., Worcester 6, Mass. *Canadian Representative:* A. P. Green Fire Brick Co., Ltd., Toronto, Ont.

NORTON
REFRACTORIES
Engineered... Rx... Prescribed
Making better products... to make your products better

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries



Up to 64 hours of operation without shutdown, under severest back slagging conditions, are reported by users of CRYSTOLON slag hole blocks — like this one, on heavy duty service in a big automotive parts foundry.



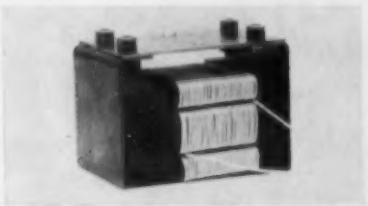
More efficient, lower cost metal-melting results when crucial points are guarded by CRYSTOLON refractories — slag hole blocks for back slagging cupolas, bricks and cement for front slagging cupolas.

by a hydraulic lift, then locked together with their open ends nesting tightly. Three-phase power is introduced, and the crucibles are resistance heated to the melting point of the tungsten and subsequently form tungsten carbide. The casting machine at the center of the furnace assembly is raised and rotates. As soon as gassing of the crucibles ceases, they are released and their contents dumped into a centrifugal mold inside the casting machine.

For further information circle No. 1093 on literature request card, p. 32-B

Ultrasonics

Harris Transducer Corp. has announced a new transducer for industrial sonic or ultrasonic processing. The elements operate at 400 to 500

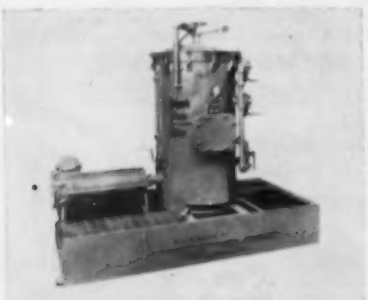


w. A single unit activates 5 to 10 gal. of water, solvent, acid or plating bath. Multiple arrays can activate very large volumes. Baths may be as hot as 160° F.

For further information circle No. 1094 on literature request card, p. 32-B

Oil Filter

Industrial Filtration Co. has announced a Superflow filter which uses diatomaceous earth with tubular filter elements. Screen elements are precoated with diatomaceous earth forming a filter cake through which the fluid passes. Cleaning is automatic and is accomplished in 1 to 3 min.

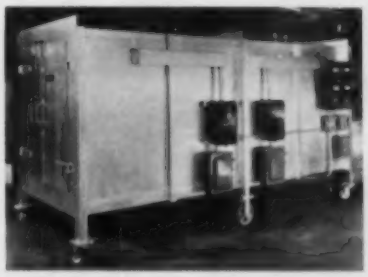


by backwashing. Liquid is forced back through the tubular filter elements from the inside. The earth cake is knocked off and allowed to settle to the cone of the filter. Agitation in the cone prevents packing of the sludge. The filter is applicable to coolants, cutting oils, hydraulic oils, industrial cleaning solvents and chemicals.

For further information circle No. 1095 on literature request card, p. 32-B

Mobile Electric Oven

The Waltz Furnace Co. has announced a mobile electric oven for preheating aluminum sheets. The oven is mounted on sturdy swivel



wheels and is capable of producing temperatures up to 750° F. It has a roller hearth and working space of 4 x 4 x 12½ ft. The oven uses 440-volt, 3-phase current.

For further information circle No. 1096 on literature request card, p. 32-B

Welding Fixture

Erico Products has announced a new 10,000 lb. horizontal pressure toggle clamp which has a 2 15/16 in.



stroke. The clamp has extra large pivot pins and all-welded construction.

For further information circle No. 1097 on literature request card, p. 32-B

Spectrometer

A small direct reading instrument for quality control on the foundry floor has been announced by Baird Assoc. It will accommodate a work load involving six elements in one matrix. New features are a sealed optical system, dust tight electronics and an automatic mechanism for maintaining optical alignment. Focal curve, entrance optics, exit slits and photomultipliers are enclosed in an airtight compartment at one end of the container. At the opposite end a smaller enclosure covers the concave diffraction grating. The entire system is sealed against dust.

For further information circle No. 1098 on literature request card, p. 32-B

PYRO

Instruments for Precision Temperature Measurements

The Simplified PYRO Optical Pyrometer



Gives accurate temperatures at a glance. Any operator can quickly determine temperatures of minute spots, fast moving objects and smallest streams. Completely self-contained, no correction charts or accessories needed. Weighs only 3½ lbs. Direct reading with special types for true pouring temperatures of molten ferrous metals. Five temperature ranges from 1400° F. to 7500° F. Ask for free Catalog No. 85.

PYRO Surface Pyrometer



Designed to meet all plant and laboratory surface and sub-surface temperature measurements with selection of thermocouples and extension arms. The improved Pyro is quick acting, accurate, light-weight and rugged. It features large 4½" direct reading scale, automatic cold end junction compensator and shielded steel housing—all combined to offer highest precision, accuracy and dependability. Available in five standard ranges from 0-300° to 0-1200° F.

Ask for free catalog No. 168.

NEW! PYRO Micro-optical Pyrometer



Designed particularly for precision temperature measurements in the laboratory, yet sufficiently portable to be used for general plant operations, the new Pyro Micro-Optical Pyrometer has been developed to meet the demand not only for higher degrees of accuracy, but also greater versatility in measurement of temperatures over 700° C.

It measures targets less than .001" in diameter, and, by means of supplementary lenses, can be adjusted for focal distances from five inches to infinity. Mountings on table-top and floor-type tripods are available, and vernier worm gears permit extremely fine vertical and horizontal adjustments of the telescope. Wide-scale, direct-reading meter makes for extremely accurate reproduction of temperatures. Ask for free catalog No. 95.

THE PYROMETER INSTRUMENT CO.
Bergenfield 21, New Jersey
New Plant and Laboratory
Manufacturers of Pyro Optical, Radiation, Immersion and Surface Pyrometers for over 25 years



MECHANICAL SEAMLESS

ELECTRIC-WELDED

AIRCRAFT SEAMLESS

AIRCRAFT MECHANICAL

FABRICATING and FORGING

OSTUCO Tubing Specialists have vast application experience in *your* industry. This storehouse of design and production know-how can improve your product and trim costs too.

OSTUCO's *single-source* service is convenient and error-free. See your nearest OSTUCO Tubing Engineer or write direct for the answer to *your* tubing problem.

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CANADA, RAILWAY & POWER ENGR. CORP., LTD.

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1101. Abrasives
36-page handbook and digest of coated abrasives—kinds, forms, uses, manufacture, limitations and proper handling. *Clover Mfg.*

1102. Adhesives
New 8-page manual on adhesive bonding. Materials, techniques, uses. *Rubber & Asbestos Corp.*

1103. Alloy Steel
207-page book gives more than 50 complete case histories of alloy steel usage. *Climax Molybdenum*

1104. Alloy Steel
16-page book on type 9115 low-alloy high-strength steel. Properties, fabrication, welding. *Great Lakes Steel*

1105. Alloy Steel
68-page "Aircraft Steels" includes revised military specifications. Also stock list. *Ryerson*

1106. Alloy Steel
32-page book on abrasion resisting steel. Properties, fabricating characteristics, uses. *U. S. Steel*

1107. Alloy Steel
Data book on the selection of the proper alloy steel grades for each manufacturer's needs. *Wheelock, Lovejoy*

1108. Alloy Tools
44-page book on cast Stellite tools for metal cutting. *Haynes Stellite*

1109. Aluminum Alloys
Selector gives the specifications for major aluminum alloys and condition used in sand and permanent mold castings. *Howard Foundry*

1110. Aluminum Alloys
Folder gives properties, fabricating characteristics, applications and size ranges of each alloy. *Peter A. Frasse*

1111. Aluminum Die Castings
Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

1112. Aluminum Extrusions
28-page book on extruded aluminum products. Design, tolerances, applications. *Revere*

1113. Annealing Copper
Reprint 55-D on how to anneal copper tubing. Furnaces, contamination control, brightening. *Surface Combustion*

1114. Atmosphere Furnace
Information on mechanized batch-type atmosphere furnaces for gas cyaniding, gas carburizing, clean hardening or carbon restoration. *Dow Furnace*

1115. Atmosphere Furnace
Bulletin on controlled atmosphere furnace. *Industrial Heating Equipment*

1116. Atmospheres
12-page booklet on design and use of special atmospheres for industrial furnaces. *Continental Industrial Engineers*

1117. Atmospheres
Bulletin 1-10 supplies technical information on inert gas generators and data on costs. *C. M. Kemp Mfg.*

1118. Atmospheres
Bulletin 439 on exothermic atmosphere generators for converting natural gas, manufactured gas, propane or butane. *W. S. Rockwell*

1119. Austempering
8-page booklet No. 500 on present status of austempering and martempering—development, S-curve theory, reasons for austempering and martempering. *Ajax Electric Co.*

1120. Barrel Finishing
32-page handbook on compounds for descaling, deburring, coloring, metal cleaning and rust inhibition. *Lord Chem.*

1121. Bearings
27-page bulletin, S-53, on self-lubricating bronze bearings, plate and bar stock. *Amplex Division*

1122. Bearings
4-page bulletin on plastic bearing materials. *Dixon Corp.*

1123. Beryllium Copper
Bulletin 1 on available alloys, conditions, tempers and tables of sizes and properties. *Penn Precision Products*

1124. Beryllium Nickel
4-page leaflet on high-strength, corrosion-resistant beryllium-nickel casting alloys. *Beryllium Corp.*

1125. Bimetal Applications
36-page booklet, "Successful Applications of Thermostatic Bimetal", describes 22 uses. *W. M. Chace*

1126. Black Oxide Coatings
8-page booklet on black oxide coatings for steel, stainless steel and copper alloys. *Du-Lite*

1127. Blackening Compounds
Bulletin on blackening compounds for ferrous alloys to AMS Spec. 2485. *Swift Industrial Chemical*

1128. Blackening Copper
Bulletin of operating instructions for blackening and coloring copper and copper alloys. *Enthone*

1129. Blackening Stainless
Bulletin on process for blackening stainless steels, cast and malleable irons. *Mitchell-Bradford*

1130. Blast Cleaning
8-page bulletin 1403 on liquid blast cleaning equipment. Drawings of cabinets. *Pangborn Corp.*

1131. Blast Cleaning
Folder on Vacu-blast room with waffle-patterned sand blast floor. *Vacu-Blast Co.*

1132. Brass
New 20-page pocket-size booklet on brass rod mill products. Weight tables, specifications and other technical data. *Titan Metal Mfg. Co.*

1133. Brazing
New bulletin on low-temperature brazing and its uses. *Handy and Harman*

1134. Brazing Alloys
Bulletin on application of six types of copper and silver brazing alloys. *United Wire & Supply*

1135. Brazing Stainless Steel
Illustrated booklet, "Bright Annealing, Hardening and Brazing Stainless Steel", describes conveyor furnace and bright brazing alloy. *Sargeant & Wilbur*

1136. Buffing and Polishing
Bulletin on automatic polishing and buffing machines of various types. *Acme Mfg.*

1137. Burners
New bulletin on Walltite injector burners for high pressure gas. *Eclipse Fuel*

1099. Arc-Cast Molybdenum

Data on unalloyed molybdenum and four arc-cast alloys is assembled in this attractive 72-page book. Tables, figures and discussion give applications (present and future), physical and mechanical properties, resistance to corrosion and oxidation, fabrication of parts, methods of production, sources of supply, and weight tables. A five-page list of references to articles published in the last six or seven years is an important feature of the book. *Climax Molybdenum Co.*



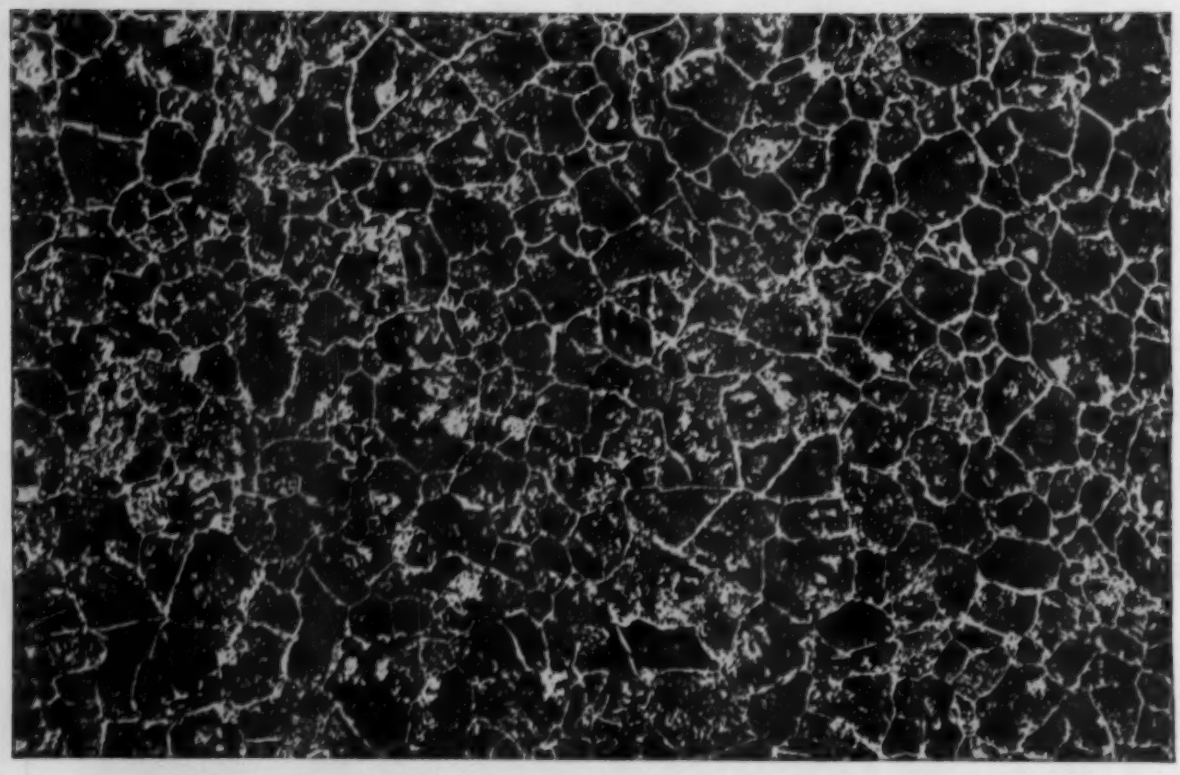
1138. Burners
8-page reprint No. 43 on Method for Improving Temperature Uniformity in Furnaces. *North American Mfg.*

1139. Carbides
84-page catalog of sintered carbides, hot pressed carbides, cutting tools, drawing dies, wear resistant parts. *Metal Carbides*

1140. Carbon Steel Castings
Data folders on four types of carbon steel castings. Composition, properties, hardenability bands, uses. *Unitcast*

1141. Carbonitriding
Literature on Ni-Carb (carbonitriding) treatment for surface hardening. *American Gas Furnace*

1142. Carbonitriding
28-page booklet on nature of process,



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NOTE the uniform grain size in this photomicrograph of Timken® forging steel. We examine every heat of Timken forging steel—spectrographically to assure uniform grain size. As a result, you can be sure that forgings made from Timken forging steels will give you uniformly high ductility and resistance to impact.

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SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

furnaces, atmospheres, parts carbonitrided and properties. *Armour Ammonia*

1143. Carbonitriding
Bulletin 241 on gas-fired radiant-tube furnace for carbonitriding and other heat treating. *Lindberg Engineering*

1144. Carburizing
Data folder on Aerocarb E and W water-solubl'e compounds for liquid carburizing. Case depth vs time curves. Per cent carbon and nitrogen penetration curves. *American Cyanamid*

1145. Castings
Literature on shell or sand castings of ArmaSteel, malleable iron or gray iron. *Central Foundry Div.*

1146. Centrifugal Castings
Bulletin on centrifugal castings of meehanite, ni-resist and special iron alloys. *Shenango-Penn Mold*

1147. Chromate Finishing
File on chromate conversion coatings for prevention of corrosion and paint-base treatment of nonferrous metals. *Allied Research Products*

1148. Cleaner
Folder gives data on metal cleaners for use with water in still-tank or spray-washing equipment. *Solventol*

1149. Cleaners
Folder on immersion, electrolytic, spray cleaners, phosphate coaters, strippers, drawing compounds, additive agents. *Northwest Chemical*

1150. Cleaning
Bulletin on equipment for cleaning and pickling of shell cases and other ordnance items. *Alvey-Ferguson*

1151. Cleaning
Data on chemical for removing scale, rust and paint from ferrous alloys. *Kelite*

1152. Cleaning
44-page booklet, "Some Good Things to Know About Metal Cleaning", discusses tank, barrel and machine cleaning, pickling, zinc phosphate coating, rust prevention and other processes. *Oakite*

1153. Cleaning
28-page catalog, B-9, on corrosion-resistant baskets, racks, crates and tanks and other fixtures for cleaning and finishing. *Rolock*

1154. Cleaning
Data sheets on acid activators to promote removal of scale and oxides from steel and iron. *Swift Ind. Chem.*

1155. Coatings
Data sheet on industrial Protectox, tarnish-resistant coating for silver, silver alloys, copper, brass and gold. *Technic*

1156. Colored Coil
Folder on aluminum, steel or other metallic coil finished in permanent colors. *Southern States Iron Roofing Co.*

1157. Compressors
12-page data book 107-D gives engineering information on characteristics of turbo-compressors. 18 types of application described. *Spencer Turbine*

1158. Continuous Cast Bronze
12-page bulletin on properties and uses of continuous cast bronze rod and tube. *American Smelting & Refining*

1159. Controlled Atmospheres
Bulletin on Dewpointer for reading of atmosphere in field and laboratory. Readily portable, operating on a.c. or enclosed battery. *Illinois Testing Labs.*

1160. Controller
New bulletin, F 5795-2, on a supplementary control device for heating equipment and straight line control on the process variable. *Wheelco*

1161. Copper Alloys
64-page book on free-cutting brass, copper and bronze. *Chase Brass*

1162. Copper Alloys
40-page handbook on phosphor bronze, nickel silver, cupro nickel, beryllium copper. *Riverside Metal*

1163. Copper Alloys
40-page book on eleven copper alloys. Properties, cleaning, annealing. *Seymour Mfg.*

1164. Copper Nickel Alloys
8-page bulletin on composition, properties and applications of series of 12 copper-nickel-base alloys available in cast form. *Waukesha Foundry*

1165. Corrosion of Copper
28-page booklet B-36 discusses corrosive attack on copper and copper alloys. Tabulation of their relative corrosion resistance. *American Brass*

1166. Corrosion Protection
23-page bulletin on Bonderite, corrosion resistant paint base. *Parker Rust Proof*

1167. Corrosion Resistance
20-page bulletin on copper alloys for corrosion resistance. Table gives applicability in 150 media. *Ampco*

1168. Corrosion Resistance
Data sheet compares corrosion properties of Elgiloy and stainless steel. *Elgin National Watch Co.*

1169. Creep Testing
Bulletin 4208 on five types of creep testing machines for standard sized metal specimens. *Baldwin-Lima-Hamilton*

1170. Creep Testing
6-page bulletin diagrams and describes dynamic creep testing machine. *Ivy Co.*

1171. Creep Testing
Data on operation and instrumentation of Arcweld lever arm creep testing machine. *Minneapolis-Honeywell*

1172. Cut-Off Wheels
Folder gives data, operating suggestions and grade recommendations of cut-off wheels. *Manhattan Rubber Div.*

1173. Cutting Oil
Facts on more efficient and economical plant operation through use of right lubricants described in "Metal Cutting Fluids" booklet. *Cities Service*

1174. Degreaser
40-page book on properties and use of trichlorethylene. Methods of handling and safety measures. *Niagara Alkali*

1175. Degreasers
Folders on vapor and solvent degreasers describe equipment and advantages. *Ramco Equipment Corp.*

1176. Degreasing
Card gives check list for efficient and economical vapor degreasing. *G. S. Blakeslee*

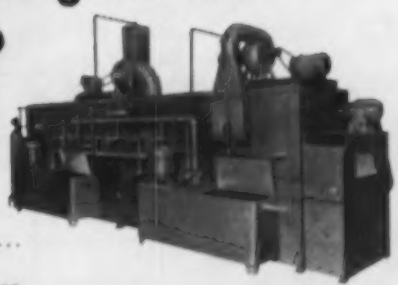
1177. Descaling Process
8-page bulletin on sodium hydride descaling process for ferrous and nonferrous metals. *DuPont*

1178. Descaling Stainless Steel
Bulletin 25 on descaling stainless steel and other metals in molten salt. *Hooker Electrochemical*

1179. Die Casting
Booklet on "High-Speed Precision Die Casting Machines". *Reed-Prentice*

1180. Die-Casting Machines
Case histories of companies using vari-

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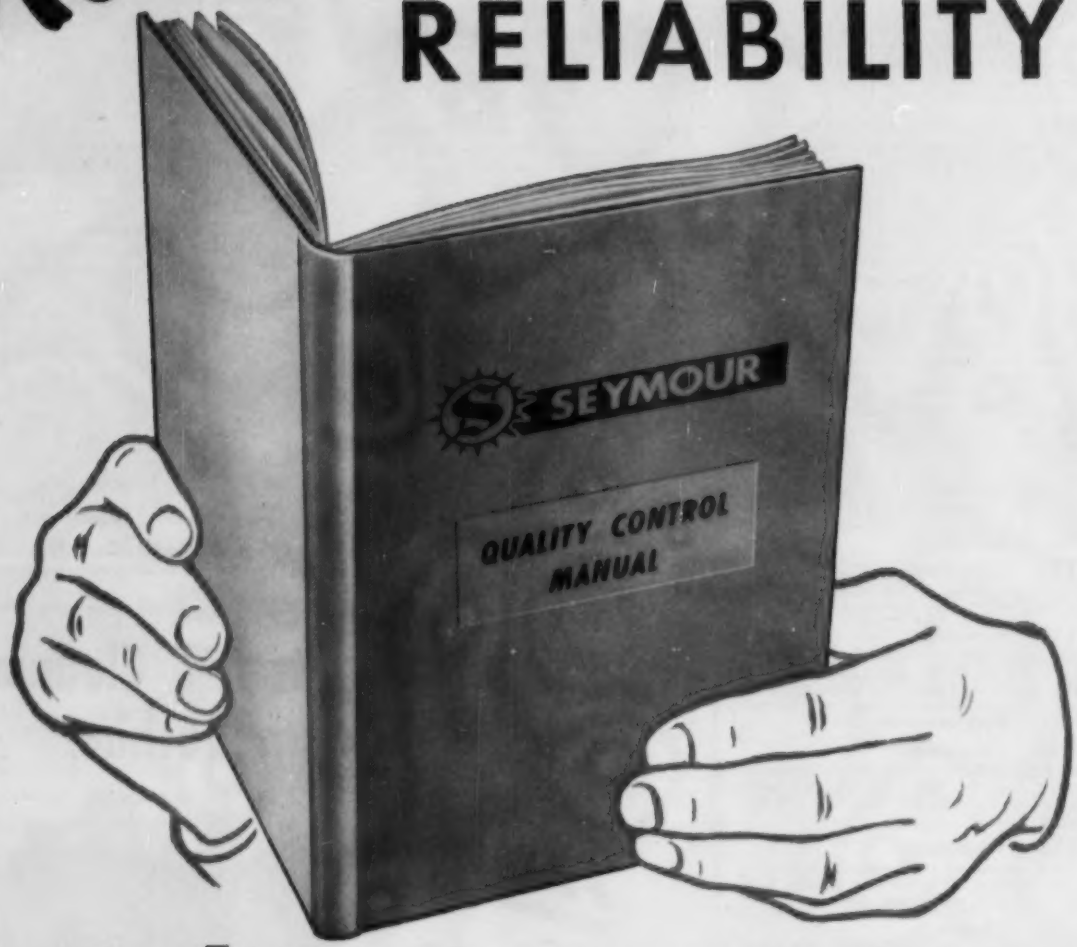
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ous types of die-casting machines. *Kux Machine*

1181. Die-Casting Machines
Copies of "Lester Press" describe various features of aluminum die casting machines. *Lester-Phoenix, Inc.*

1182. Die Castings
Booklet on small zinc die castings. Types that can be made. Properties of zinc die casting alloys. *Gries Reproducer*

1183. Dryers
24-page bulletin No. 222 shows installations of air drying equipment in various industries. *Pittsburgh Lectrodryer*

1184. Ductile Iron
32-page book on types of ductile iron, wear resistance, machinability, weldability, heat treatment and mechanical properties. *International Nickel*

1185. Electric Furnaces
Catalog of electric furnaces and ovens for hardening, tempering, annealing, drawing, drying, baking, enameling. *Cooley Electric Mfg.*

1186. Electric Furnaces
Bulletin on electric heat treating furnaces gives summary of progress in furnace developments. *Holcroft*

1187. Electric Furnaces
Brochure on electric heat treating, melting, metallurgical tube, research and sintering furnaces. *Pereny Equipment*

1188. Electric Melting
Bulletin 527 on compact arc furnace. Melt time and power consumption for four alloys. *Detroit Electric Furnace*

1189. Electron Microscope
New 20-page booklet on special features and uses of electron microscope. *RCA*

1190. Electroplating
Bulletin on electroplating lists key characteristics of 16 processes. *Hanson-VanWinkle-Munning*

1191. Extrusion Presses
8-page bulletin on aluminum extrusion presses describes the process and presses at work. *Watson-Stillman*

1192. Fabrication
Booklet on welded steel heavy fabrication pictures and describes how various products are made. *R. C. Mahon*

1193. Filters
Folder F 10-54 on filters for electroplating, waste liquids and solvents. *Wagner Bros.*

1194. Finishes
Pocket-sized booklet covers blackening compounds, alkaline cleaners, strippers, lacquers, rust removers. *Enthone*

1195. Finishing
52-page book "Advanced Speed Finishing" describes equipment for deburring and finishing. *Almco Div.*

1196. Finishing
Six bulletins describing finishing compounds for stainless steel, aluminum, other metals. *Apothecaries Hall*

1197. Finishing
Catalog of protective finishes and heat treating salts; rust preventives, blackening compounds. *Mitchell-Bradford*

1198. Finishing Stampings
New bulletin on finishing of stamped metal parts by abrasive blasting. *Wheelabrator*

1199. Flame Hardening
20-page booklet on precision flame hardening machine with electronic control. Details of operation and applications. *Cincinnati Milling Machine*

1200. Flame Plating
16-page booklet lists advantages, properties, specifications of flame-plated tungsten carbide coating. *Linde*

1201. Flaw Detection
Details about new full-color training movie on dye-penetrant methods of flaw detection. Film shows production applications, as well as explanation of the method. *Turco Products*

1202. Flow Meters
Bulletin 201 on flow meter for gas used in heat treating. *Waukee Eng'g*

1203. Forging
20-page booklet 155 on various kinds of forging hammers. Specifications, descriptions. *C. C. Bradley & Son*

1204. Forging
20-page bulletin 355 on steam drop hammers. Dimension, designs, construction. *Erie Foundry Co.*

1205. Forgings
94-page book on die blocks and heavy-duty forgings. 20 pages of tables. *A. Finkl*

1206. Forgings
Folder on large forgings of carbon and alloy steel. *Struthers Wells Corp., Titusville Forge Div.*

1207. Forming Dies
Folder on styles of forming dies for stainless heads—in wide range of sizes and gages. *Carlson*

1208. Foundry Practice
Bulletin on new method of coring intricate passageways in castings. *Hills-McCanna*

1209. Fuel Gas
Bulletin on gas for cutting, brazing, metallizing, flame hardening, carburizing and heat treating. *Pyrofax Gas Co.*

1210. Furnace Belts
44-page catalog describes metal belts for quenching, tempering, carburizing and other applications. *Ashworth Bros.*

1211. Furnace Charging
12-page brochure on eight models of charging machines for heating and melting furnaces. *Salem-Brosius*

1212. Furnace Fixtures
Bulletin 111 on cast Ni-Cr fixtures for gas carburizing. *Fahralloy*

1213. Furnace Fixtures
16-page catalog on baskets, trays, fixtures and carburizing boxes for heat treating. 66 designs. *Stanwood Corp.*

1214. Furnaces
High temperature furnaces for temperature up to 2000° F. are described in bulletin. *Carl-Mayer Corp.*

1215. Furnaces
Bulletin on specially designed continuous production furnaces for brazing, sintering, bright annealing, heat treating, bar heating, melting, forging. *Harper Electric Furnace Corp.*

1216. Furnaces
44-page Catalog 112, features furnaces for hardening, tempering, carbonitriding, forge heating, sintering, annealing and tool heat treating. Also atmosphere generators and ammonia dissociators. *C. I. Hayes*

1217. Furnaces
Data on luminous wall forging furnaces. *A. F. Holden*

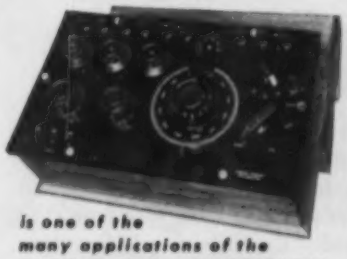
1218. Furnaces
Folder on recuperative atmosphere furnaces for operation to 2500° F. *Lithium*

1219. Furnaces
Bulletin on electric heat treating furnaces describes five series and accessories. *Lucifer Furnaces*

1220. Furnaces
Folder giving drawings, dimensions,

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Described in Bulletin 320

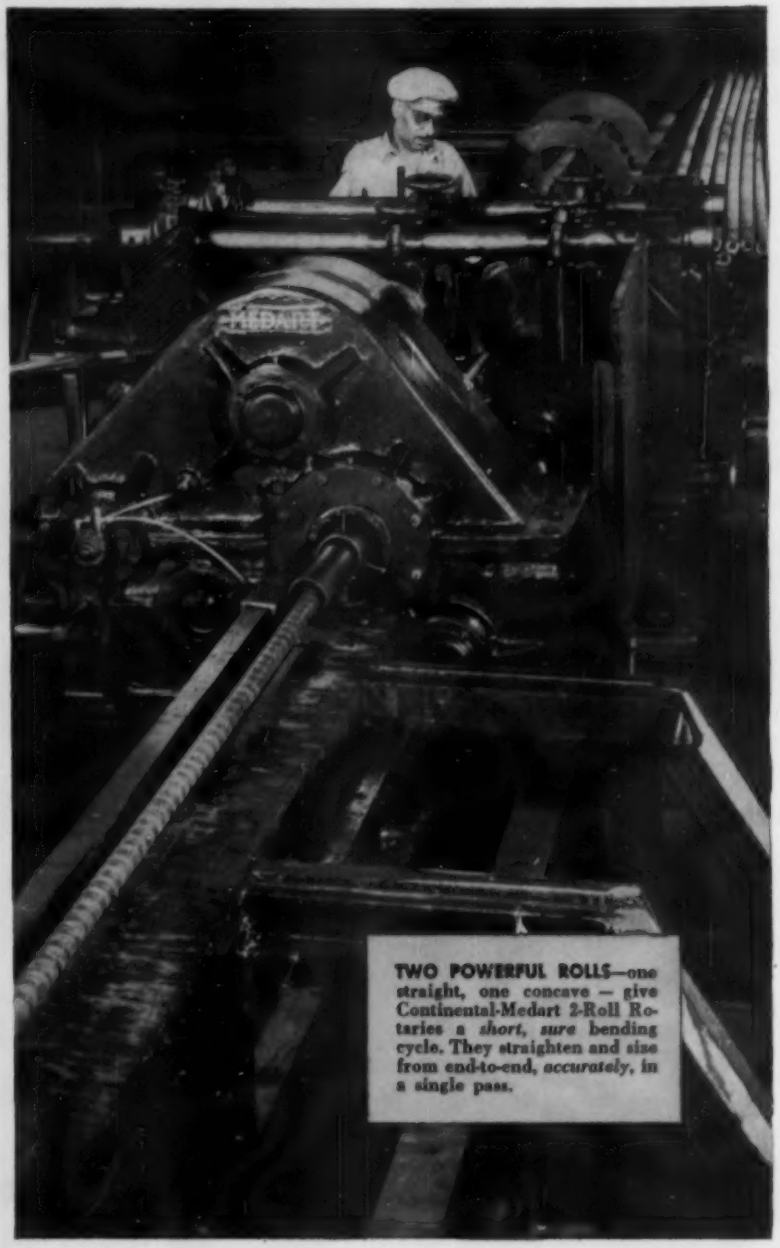
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capacity, Btu. required for drawing, annealing, forging. *Gas Machinery*

1221. Furnaces, Heat Treating
32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

1222. Furnaces, Heat Treating
12-page bulletin on conveyor furnace, radiant tube gas heated, oil or electrically heated. *Electric Furnace Co.*

1223. Furnaces, Heat Treating
Bulletin on furnaces for annealing, normalizing, hardening, tempering, forging. *Flinn & Dreffein Eng'g.*

1224. Gamma Ray Projector
Data on three radiation projectors for nondestructive testing and inspection. *Metal & Thermit*

1225. Gas Generator
Bulletin G-16A on gas-fired and electric endothermic generators. Specifications. *Ipsen Industries*

1226. Globar Furnaces
Bulletin 153 describes nine types of furnace using silicon carbide heating elements for temperatures to 2600° F. *Hevi Duty*

1227. Graphite
6-page revised bulletin No. 435 on colloidal graphite for surface coatings and impregnation. *Acheson Colloids*

1228. Graphite
20-page brochure on significance of graphite as electrodes, anodes, molds and specialties in electrometallurgy and electrochemistry. *Great Lakes Carbon*

1229. Graphite Molds
Data on two types of molds for casting magnesium, steel, copper, brass and other metals. *National Carbon*

1230. Graphitic Tool Steels
48-page booklet on heat treating data, properties and 46 specific applications of graphitic tool steel. *Timken*

1231. Grinding Magnesium
Data on how to grind and polish magnesium alloys includes grinding wheel recommendations, procedures, dust collection and safety precautions. *Norton*

1232. Handling Devices
Pamphlets on clamps for lifting and handling. Their application to various industries. *Merrill Bros.*

1233. Hardness Numbers
Pocket-size table of Brinell hardness numbers incorporating other tabular information. *Steel City Testing*

1234. Hardness Tester
Bulletin on Impressor portable hardness tester for aluminum, aluminum alloys and soft metals. *Barber-Colman*

1235. Hardness Tester
20-page book on hardness testing by Rockwell method. *Clark Instrument*

1236. Hardness Tester
Literature on Brinell testing machines. *Detroit Testing Machine Co.*

1237. Hardness Tester
Bulletin RH-12-54 on portable hardness tester for Rockwell readings. *Riehle*

1238. Hardness Testers
Bulletin No. A-12 on new Wolpert-Gries machine for making Rockwell hardness tests. *Gries Industries*

1239. Hardness Testers
Catalog of testers for normal hardness, superficial testing, accessory and special testing and micro and macro hardness testing. *Wilson Mechanical Instrument*

1240. Hardness Testing
Bulletin KG-51 on 3000 kg. proving ring for calibrating Brinell hardness testers. *Morehouse Machine*

1241. Hard Surfacing
Folder on tungsten carbide hard surfacing weld rods. *Coast Metals*

1242. Heat Absorption
32-page booklet on rate of heat absorption of steel gives method for calculating heating rate. *Bloom Eng.*

1243. Heat Resistant Alloy
10-page article on how to get best service out of standard grades of heat resisting alloys by proper selection. *Rolled Alloys*

1244. Heat Resistant Castings
16-page bulletin on design, engineering, foundry practice, inspection and testing of Thermalloy castings. *Electro Alloys*

1245. Heat Treating
16-page booklet on cost accounting for heat treating. *Metal Treating Institute*

1246. Heat Treating
Loose leaf data sheets on heat treating oils, salts, carburizing compounds. *Park Chemical*

1247. Heat Treating
8-page bulletin on continuous heat treating. Flow diagrams, equipment. *Surface Combustion*

1248. Heat Treating
Bulletin 14-T on ovens for heat treatment of aluminum and other low-temperature processing. *Young Bros.*

1249. Heat Treating Ammonia
24-page "Guide for Use of Anhydrous Ammonia" describes heat treating and other metallurgical uses. *Nitrogen Div.*

1250. Heat Treating Equipment
4-page folder of 17 different types of industrial heat treating equipment. *Ferguson Equipment Corp.*

1251. Heat Treating Fixtures
24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*

1252. Heat Treating Fixtures
12-page bulletin on wire mesh baskets for heat treating and plating. *Wiretex*

1253. Heat Treating Guide
Chart guide constructed on slide rule principle for simplified hardening and drawing of tool steels. *Carpenter Steel*

1254. Heat Treating Pots
6-page bulletin lists sizes available in Thermalloy. Suggestions on increasing service life. *Electro-Alloys*

1255. Heating Elements
24-page Bulletin H on electric heating elements. Includes extensive tabular data on physical and electrical specifications for various sizes. *Globar Div.*

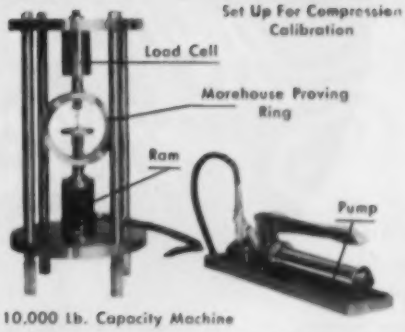
1256. High Alloy Castings
New 16-page bulletin, No. 3354-G, gives engineering data concerning castings used for resisting high temperatures, corrosion and abrasion. *Duraloy Co.*

1257. High-Strength Steel
26-page booklet on properties, uses, applications of high tensile low-alloy steel. *Jones & Laughlin*

1258. High-Temperature Steels
87-page book on factors affecting high-temperature properties. 45 pages of data on tensile, creep and rupture properties of 21 high-temperature steels. *U. S. Steel*

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1259. High-Vacuum Furnaces
12-page brochure No. 790 on vacuum furnaces for melting and casting titanium, zirconium, germanium, copper, iron and steel. Also furnaces for annealing, hardening, brazing. *F. J. Stokes*

1260. Immersion Heating
4-page bulletin H-11 on correct selection, sizing and installation of equipment for immersion heating. *Eclipse Fuel Eng.*

1261. Impregnant
Data Sheet No. 1 on metal oxide-type sealer for castings of brass, bronze, gray iron, malleable iron, ductile iron, steel, aluminum, zinc and magnesium. *Prenco Products*

1262. Induction Heaters
New bulletin on low-frequency induction heating describes units for brass, copper, titanium, steel, forgings, light metal extrusion presses. *Magnethermic*

1263. Induction Heating
12-page Bulletin 13-A on high frequency induction furnace for forging, upsetting, spinning, annealing, hardening. *Ajax Electrothermic*

1264. Induction Heating
Bulletin on high frequency induction heaters. Application and equipment. *Electric Arc*

1265. Induction Heating
36-page bulletin on high-frequency induction heating unit for brazing, hardening, soldering, annealing, melting and bombarding. *Lepel*

1266. Induction Heating
60-page catalog tells of reduced costs and increased speed of production on hardening, brazing, annealing, forging or melting jobs. *Ohio Crankshaft*

1267. Industrial Fans
Catalog 370 on fans for handling high temperature gases at all pressures. *Garden City Fan*

1268. Instruments
Catalog of thickness gages, tensile testers, recorders, pressure gage testers, tachometers. *Amthor Testing Instrument*

1269. Instruments
Catalog 12-A-10 on instruments for indicating, recording, controlling, temperatures from —400 to +1000° *F. Fischer & Porter*

1270. Iron Powder
Bulletin on production of iron powder for flame cutting, scarfing, powder metallurgy, electronics and chemical applications. *Easton Metal Powder*

1271. Insulation
40-page industrial products catalog on insulations, refractory products, and others. *Johns-Manville*

1272. Joining Stainless
24-page booklet on various welding methods, soldering, brazing, flame cutting and arc cutting of stainless. *Crucible*

1273. Laboratory Furnace
Bulletin RT-10 on 25 lb. per hr. laboratory metal treating unit for carburizing, hardening, carbonitriding, brazing, carbon restoration. *Ipsen*

1274. Laboratory Mill
4-page reprint on rolling mill for laboratory studies, which may be operated as a 2-high, 3-high or 4-high mill. *Fenn Mfg.*

1275. Laboratory Supplies
Instruments and apparatus for control, research, development laboratories. *Harshaw Scientific*

1276. Leaded Steel
8-page booklet on production of lead treated steels, their advantages and case histories of their use. *Copperweld Steel*

1277. Light Metal Castings
Bulletin "Creative Castings" on making castings of aluminum and magnesium. *Thompson Products, Light Metals Div.*

1278. Lubricant
8-page folder describes use of molybdenum disulfide lubricant in cold forming, cold heading and other applications. Case histories. *Alpha Corp.*

1279. Machining Costs
12-page "Relation of Machining Time to Material Cost". Comparative machinability costs per ton for eleven steels. *La Salle Steel*

1280. Magnesium Extrusions
36-page bulletin gives values of moment of inertia, section modulus and radius of gyration of bars, tubing, angles, channels, tees, zees and other sections. *Dow Chemical*

1281. Magnesium Specs
Bulletin DM12n on specifications of government agencies, AMS, SAE, ASTM. *Dow Chemical*

1282. Malleable Iron
12-page Bulletin 5797 on electric-furnace annealing of malleable iron. *General Electric*

1283. Melting Furnace
Bulletin gives specifications, diagrams, performance and other technical data on Simplex melting furnaces. *Lindberg Engineering*

1284. Melting Furnaces
28-page catalog on Heroult electric melting furnaces. Types, sizes, capacities, ratings. *American Bridge*

1285. Metal Powders
Folder on a series of nickel-base alloys for hard surfacing and brazing. *Coast Metals*

1286. Metallurgical Products
Chart of typical chemical analysis and commercial uses of zirconium oxides, silicates, soluble salts, metallurgical and foundry alloys. *Titanium Alloy Mfg.*

1287. Microhardness Tester
Bulletin describes the Kentron microhardness tester. *Torsion Balance Co.*

1288. Micropolishing
10-page brochure on units for polishing coils, blanks and sheets. *Murray-Way*

1289. Microscopes
22-page catalog describes microscopes featuring ball bearings and rollers throughout the focusing system and a low-position fine adjustment, providing comfortable operation. *Bausch & Lomb*

1290. Microscopes
Catalog on metallograph and several models of microscopes. *United Scientific*

1291. Mixers
32-page booklet on 1 to 500 hp. mixers, construction, operation, applications. *Mixing Equipment Co.*

1292. Molybdenum
24-page booklet gives physical and chemical property data on molybdenum powders, wire, alloys. *Sylvania Electric*

1293. Nickel Chromium Steels
8-page bulletin with 28 charts on composition, heat treatment, transformation characteristics and mechanical properties of the standard nickel-chromium steels. *International Nickel*

1294. Nickel Powders
Data sheets PMS 72 and 73 on chemical and physical properties of two grades of electrolytic nickel powder. *National Radiator, Plastic Metals Div.*

1295. Nondestructive Testing
8-page bulletin on equipment for non-



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RA 310.....25% Cr—20% Ni
RA 430.....17% Cr
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REFRACTORIES
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destructive testing of bars, rods, tubing. *Magnetic Analysis*

1296. Nondestructive Testing
Series of bulletins gives data on both ultrasonic and magnetic testing instruments. *J. W. Dice Co.*

1297. Nuclear Radiation Cell
Data on industrial instrumentation applications of the Ohmart cell, the radioactive sensitive element which converts nuclear radiation into electrical energy. *Minneapolis-Honeywell*

1298. Oil Quenching
8-page brochure tells in detail how carbon steel often can replace alloy steel when additive is used in the quenching oil. *Aldridge Industrial Oils*

1299. Oil Quenching
Catalog V-1146 on self-contained oil cooling equipment. Selection tables for volume of oil required and oil recirculation rates. *Bell & Gossett*

1300. Periodic Chart
Periodic chart of the elements, green and black, 11 by 14 in., official 1952 data. *General Electric*

1301. Photomicrography
Folder on universal photomicrographic camera describes appliance and its uses, and accessories. *Brinkman Instruments*

1302. Pickling
80-page book "Efficient Pickling" covers all variables of process. Many charts and tables. *American Chemical Paint*

1303. Pickling Baskets
Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

1304. Pickling Baskets
12-page bulletin on mechanical picklers, crates, baskets, chain and accessories. *Youngstown Welding & Eng'g*

1305. Plating
12-page booklet, "Guide to Better Plating Power", describes selenium rectifiers for different applications. *Bart-Messing*

1306. Plating
4-page bulletin on portable plater describes unit and gives its specifications. *Sel-Rex Precious Metals*

1307. Plating Solutions
Operating manuals for plating with metal fluoborate solutions. *Baker & Adamson.* See page 213.

1308. Plating Solutions
Bulletin 12 on electric heating of pickling and plating solutions. *Pyrosil*

1309. Potentiometers
Data on single, double and triple range portable potentiometers. *Leeds & Northrup*

1310. Potentiometers
Article gives technical data on semi-precision potentiometers. *Rubicon*

1311. Powder Metallurgy
12-page bulletin B-101 on furnaces for sintering powder metal products and reduction of metallic oxides. *Drever Co.*

1312. Powdered Metals
Bulletin 800-B on pre-alloyed iron powders with varied chromium-nickel contents. *Metal Hydrides*

1313. Precision Casting
12-page book on alloy selection and design for precision casting. *Arwood Precision Casting*

1314. Precision Casting
8-page bulletin on investment castings of various ferrous and nonferrous alloys. *Engineered Precision Casting*

1315. Precision Castings
16-page booklet includes composition and properties of carbon, low alloy, stainless, high temperature and tool steel precision castings. *Crucible Steel*

1316. Precision Castings
20-page book on alloys used, specification ranges, advantages and castings made by precision casting. *Haynes Stellite*

1317. Pure Metals
Data sheets on vacuum melted cobalt, copper, iron and nickel. *Vacuum Metals*

1318. Pyrometers
12-page Bulletin 713 on indicating and controlling pyrometers. Functional diagrams of installations. *General Electric*

1319. Pyrometers
New bulletin, "Temperature Indications," on basic facts about pyrometry and line of pyrometers. *Illinois Testing Labs.*

1320. Pyrometers
4-page booklet on infrared radiation pyrometers. *Servo Corp.*

1321. Pyrometers
New bulletin, F 6048-1, on indicating pyrometers in ranges up to 3600° F. *Wheelco*

1322. Quench Furnaces
Bulletin 700 on cataract quench furnaces for austempering and martempering. *Ajax Electric*

1323. Quenching
Bulletin 120 on use of heat exchangers to provide heat control in quenching bath. *Niagara Blower*

1324. Quenching
24-page booklet on agitation of quenching mediums. Engineering of agitator installations. *U. S. Steel*

1325. Quenching Oil
New book on mechanism of quenching, properties of quenching mediums, cooling curves. *Gulf Oil*

1326. Quenching Oil
10-page book on new oils for the quenching process gives results on hot wire quench test and in plant operation. *Sinclair Refining Co.*

1327. Quenching Oil
8-page booklet on applications and cost reductions in oil-quenching installations. *Sun Oil*

1328. Radioactive Chemicals
22-page book on radioisotope reagents, how they are used in research. Lists 130 organic and inorganic radioisotopes. *General Chemical Div., Allied Chemical and Dye Corp.*

1329. Radiography
28-page booklet on products for industrial radiography gives exposure and processing data for various films used. *DuPont*

1330. Radiography
Bulletins JR and AR on one and two million volt X-ray generator. *High Voltage Engineering Corp.*

1331. Rare Earths
8-page Progress Report Number 1, "Rare Earths in Iron and Steel Melting". *Molybdenum Corp.*

1332. Recorders
New 12-page bulletin contains methods of applying 6-in. strip-chart recorders for pressure, liquid level, temperature, flow, mechanical motion. *Bristol*

1333. Recorders
Literature on multiple point recorders, recorder controllers and indicating controllers. *Weston Instrument*

1334. Refractories
New 24-page bulletin on physical and

(Continued on page 32-A)

keeping up with

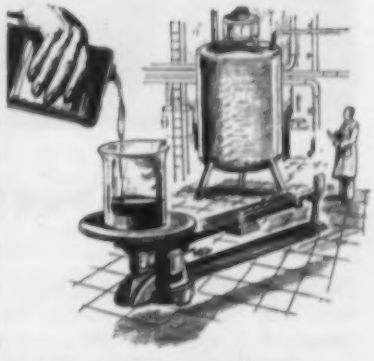
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Disperse a pound of sodium in inert hydrocarbon media at a particle size of 15 microns and you've got 278 billion separate particles—a tremendous, highly-active surface area. Many a reaction, too slow for commercial consideration before U.S.I. developed sodium dispersions, now finds ready acceptance as a full-scale plant process — with high yields and remarkable ease of control. Even greater surface area can be obtained by coating sodium on inert free-flowing solids, another U.S.I.-developed technique.

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UNDER PRESSURE? TRY 4500 PSI AT 1150 F

There's a new concept in big boiler design: The Universal Pressure Steam Generator. It operates either below the critical—3206 psi—or smashes through the pressure barrier. A unit now being built has a design pressure of 5500 psi, delivers steam at 4500 psi and 1150 F. It's a "once-through" unit; put water in one end of a tube and steam comes out the other, without using a steam drum.

When B&W engineers designed this new boiler they turned to their own metallurgical and tubular products experience with alloys for pressure and temperature service to devise the tubing complex that is the heart of the unit. The chart shows the variety of analyses in sizes from 1-inch O.D. to 2½-inch O.D. and wall thicknesses from 0.10-inch to 0.55-inch.

Carbon Steel • Carbon Moly
Croloy ½ • Croloy 1
Croloy 1¼ • Croloy 2¼
Croloy 3M • Croloy 9M
Croloy 18-8

The best way to avoid operating under *personal* pressure on any job is to call for B&W Pressure Tubing. There's a grade, size, length and wall for virtually every pressure, temperature and corrosion resistance requirement. *Write for Technical Bulletin 6-MP.*

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TUBULAR PRODUCTS DIVISION
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Alliance, Ohio: Welded Carbon Steel Tubing
Milwaukee, Wis: Seamless Welding Fittings

TA-5028(P)

(Continued from p. 31)
chemical properties of super refrac
Applications. *Refractories Div., C*
rundum

1335. Refractory Coating
Data on aluminum oxide and
carbide coating which may be s
on. *Norton Co.*

1336. Roll Forming
Bulletin 854 on roll forming o
rolled shapes. *American Roller Die*

1337. Rust Preventives
12-page bulletin on water-solubl
preventive. *Production Specialties*

1338. Salt Bath Descalin
12-page bulletin B-40 describes
uous and batch descaling lines f
moving oxide from steel, bronze,
stainless and titanium. *Drever*

1339. Salt Bath Furnace
Data on electric, gas salt bath fu
Bellis

1340. Salt Bath Furnace
Data on salt bath furnaces for
and conveyorized work. *Upton*

1341. Salt Baths
32-page bulletin on salts for tem
annealing, neutral hardening, mart
ing and carburizing. Heat treatin
E. F. Houghton

1342. Sand Control
New 4-page bulletin on line of f
sand testing equipment illustrate
unit and gives details of constructi
application. *Claud S. Gordon*

1343. Saws
Catalog C-53 describes 35 mo
metal-cutting saws. *Armstrong-Bl*

1344. Seamless Tubing
Folder TB-360 on parts which
made of seamless mechanical tu
alloy steel. *Babcock and Wilcox*

1345. Selective Strippers
Bulletin on materials for selectiv
ping of one metal from another—
plated metals, solder or brazing
Enthone

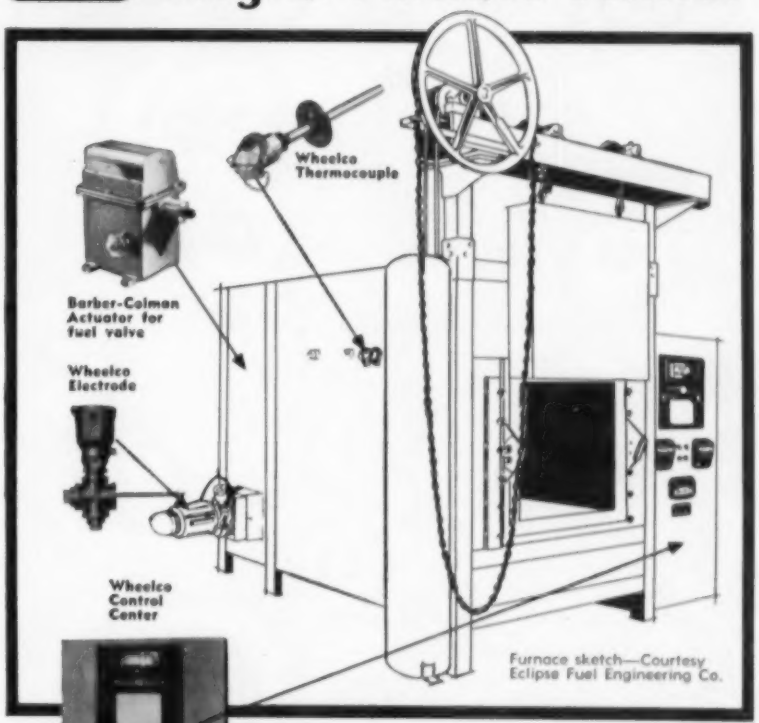
1346. Sheet Polishing
Discussion of new techniques fo
metal polishing. *Acme Mfg. Co.*

1347. Shell Molding
8-page technical bulletin on shel
ing process for stainless steel.
Alloy Foundry

1348. Shotblasting
16-page "Primer on the Use of S

BARBER COLMAN

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Newest, most efficient solution to related temperature and combustion control problems on furnaces

Integrated furnace control, completely packaged by one reliable, experienced manufacturer can be the solution to many problems. This type of system is now possible because of the development of Wheelco Control Centers, designed and engineered to provide a simple method of housing combustion safeguards, pilot lights, alarms, plus all other components and instruments of a complete combustion safeguard system.

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UND

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Generator. It ope
critical—3206 psi
the pressure barri
built has a design
delivers steam at
It's a "once-throu
one end of a tub
the other, without

When B&W e
new boiler they
metallurgical and
perience with all
temperature servi
complex that is
The chart shows
in sizes from 1-i
O.D. and wall
inch to 0.55-inch

(*Continued from p. 31*)

chemical properties of super refractories. Applications. *Refractories Div., Carborundum*

1335. Refractory Coating

Data on aluminum oxide and silicon carbide coating which may be sprayed on. *Norton Co.*

1336. Roll Forming

Bulletin 854 on roll forming of cold rolled shapes. *American Roller Die Corp.*

1337. Rust Preventives

12-page bulletin on water-soluble rust-preventive. *Production Specialties*

1338. Salt Bath Descaling

12-page bulletin B-40 describes continuous and batch descaling lines for removing oxide from steel, bronze, copper, stainless and titanium. *Drever*

1339. Salt Bath Furnaces

Data on electric, gas salt bath furnaces. *Bellis*

1340. Salt Bath Furnaces

Data on salt bath furnaces for batch and conveyorized work. *Upton*

1341. Salt Baths

32-page bulletin on salts for tempering, annealing, neutral hardening, martempering and carburizing. Heat treating data. *E. F. Houghton*

1342. Sand Control

New 4-page bulletin on line of foundry sand testing equipment illustrates each unit and gives details of construction and application. *Claud S. Gordon*

1343. Saws

Catalog C-53 describes 35 models of metal-cutting saws. *Armstrong-Blum*

1344. Seamless Tubing

Folder TB-360 on parts which may be made of seamless mechanical tubing of alloy steel. *Babcock and Wilcox*

1345. Selective Strippers

Bulletin on materials for selective stripping of one metal from another—electroplated metals, solder or brazing excess. *Enthone*

1346. Sheet Polishing

Discussion of new techniques for sheet metal polishing. *Acme Mfg. Co.*

1347. Shell Molding

8-page technical bulletin on shell molding process for stainless steel. *Cooper Alloy Foundry*

1348. Shotblasting

16-page "Primer on the Use of Shot and Grit". Problems of blast cleaning operations. *Hickman, Williams*

1349. Silver Brazing

48-page manual on all aspects of silver brazing applications and problems. *American Platinum Works*

1350. Silver Brazing

Series of eight technical bulletins on silver brazing. Joint strength, design, stress analysis, heat treatment, fluxes. *Handy & Harman*

1351. Sintered Carbides

New 24-page booklet on the characteristics of the various grades, for research and design engineers. *Kennametal*

1352. Slitting

76-page book on slitting lines for coils and sheets. Design, selection, operation, time studies of operating cycle. *Yoder*

1353. Sodium

New 28-page booklet on using sodium in dispersed form tells how dispersions are prepared and handled, and their advantages. *Ethyl Corp.*

1354. Sodium Metal

24-page book on sodium in colloidal form, spread over inert solids of high surface area. *U.S. Industrial Chem.*

1355. Specification Key

Guide to Government specifications for phosphatizing, rustproofing and paint bonding chemicals. *American Chemical Paint*

1356. Spectrograph

24-page booklet on Echelle spectrographs. Advantages. Type of work produced. *Bausch & Lomb*

1357. Spectrograph

Applications of the Ebert spectrograph with order sorter at high dispersion settings in Jaco News Letter. *Jarrell-Ash*

1358. Spring Steels

Spring steel catalog offers 785 sizes of hardened and tempered spring steels, and 133 cold rolled and bright annealed sizes in stock. *Sandvik Steel*

1359. Stainless Castings

New booklet on stainless castings in design of food processing equipment. *Alloy Casting Institute*

1360. Stainless Steel

12-page booklet on new AM 350 chromium-nickel-molybdenum stainless steel which is hardenable by subzero cooling or double aging. *Allegheny Ludlum*

1361. Stainless Steel

Wall chart gives engineering properties of 20 different stainless steel alloys available in wire, rod, strip. *Alloy Metal Wire*

1362. Stainless Steel

Slide chart. Set top at a certain fabricating operation, bottom shows rating of each standard grade. On reverse side, heat treating and corrosion data are given. *Carpenter Steel*

1363. Stainless Steel

36-page bulletin on effect on properties of processing at different temperatures. *International Nickel*

1364. Stainless Steels

20-page book on uses of stainless steels. *Electro Metallurgical*

1365. Stainless Wire

New 32-page aid to selection of proper stainless steel wire for particular application discusses austenitic, ferritic and martensitic grades. *Crucible Steel*

1366. Stamping

12-page catalog on stamping, drawing, forming and heading. *Plume & Atwood*

1367. Steel

Data on alloy and stainless steels in billets, slabs, hot rolled and cold finished bars. *Rotary Electric Steel*

1368. Steel

36-page guide to specialty steels includes tool and die steels, stainless steels, silicon and high nickel alloys. *Carpenter Steel*

1369. Steel

Bulletins on hot work steel and Type 420 stainless give forging, annealing and hardening characteristics. *Firth Sterling*

1370. Steel Tubing

48-page Handbook F-3 on fabricating and forging steel tubing. Bending, shaping, cutting and joining operations described. *Ohio Seamless Tube*

1371. Sub-Zero Treatment

New 12-page booklet on industrial chilling equipment for shrinking, testing and treating of metals. *Cincinnati Sub-Zero Products*

1372. Tanks and Linings

16 pages of data on tanks and corrosion-resistant linings for cleaning and plating solutions. *Chemical Corp.*

1373. Temperature Control

Data Sheet on radiation-type temperature detectors. *Leeds & Northrup*

1374. Test Service

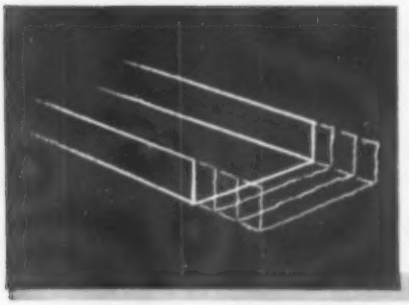
Literature on services specializing in atmospheric and sea water corrosion testing. *South Florida Test Service*

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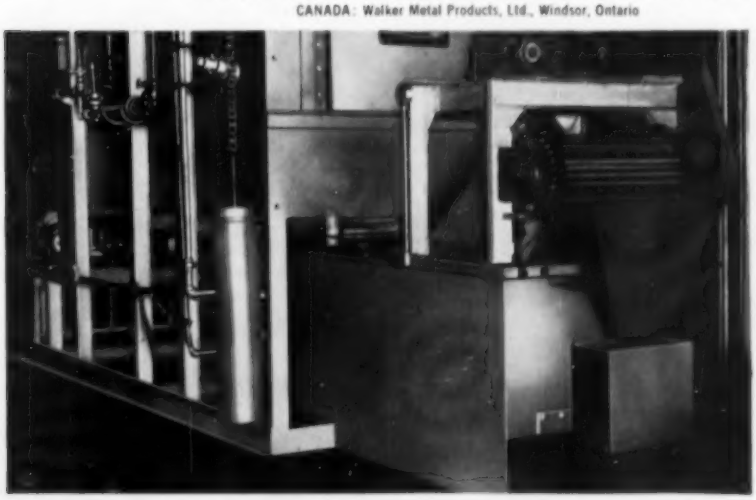
The work is either manually or automatically placed directly on a hearth which is designed to move forward quickly a few inches, stop suddenly, and then return to its original position. The sudden jolt slides the parts through the furnace. An alternate arrangement is set up so that the hearth moves forward slowly, halts, then snaps back to its original position. Either method assures uniform heat treatment of each individual part.

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CANADA: Walker Metal Products, Ltd., Windsor, Ontario



1375. Test Specimens
Data on machine for cutting test specimens to ASTM specifications. *Sieburg Industries*

1376. Tester
Bulletin 164 on Dyhedron, dynamic diamond tester for hardness and lubricity of materials. *Taber Instrument*

1377. Testing Machines
8-page folder on Amsler machines for tests in tension, compression, torsion, shear, fatigue, bending and ductility. *Buehler*

1378. Testing Machines
Universal testing machines and equipment are diagrammed, described and illustrated in 20-page Bulletin 43. *Tinius Olsen*

1379. Textured Steel
New booklet on surface rolled patterns in steel. *Sharon Steel Corp.*

1380. Thermocouple Tubes
New 4-page bulletin on standard thermocouple protecting tubes and wells. *Claud S. Gordon*

1381. Thermocouples
36-page Bulletin 235-4 describes various types of thermocouples, extension wire and other accessories. *Foxboro*

1382. Thermocouples
8-page bulletin 31-H on thermocouple and extension wires, insulations, gages, calibrations, color codes. *Thermo Electric*

1383. Thermocouples
32-page file book on pyrometer accessories. Selection of thermocouple and protective tube. *West Instrument Corp.*

1384. Thermometers
Specification Sheet 602 on internal cam programmer thermometers designed to maintain a definite relationship between temperature and time. *Minneapolis-Honeywell*

1385. Thickness Testers
6-page catalog on Audigage thickness testers. Characteristics and applications of five models. *Branson Instruments*

1386. Tin
20-page booklet describes mining of tin and its present use by American industry. *Malayan Tin Bureau*

1387. Titanium Alloy
Data on ternary alloy with 3% aluminum and 5% chromium gives physical properties, forging temperatures, high temperature characteristics. *Mallory-Sharon Titanium*

1388. Titanium Tubing
Bulletin No. 42 on properties, applications and advantages of titanium tubing. *Superior Tube Co.*

1389. Tool & Die Steels
28-page guide to qualities and sizes available. *Uddeholm*

1390. Tool Steel
Data sheets on high speed, hot work, air, oil and water hardening tool steels, alloy steels, machinery steels, stainless steels, welding rods. *Crucible Steel*

1391. Tool Steel Color Guide
Color guide to estimate temperatures has heat colors on one side and temper colors on the other. *Bethlehem Steel*

1392. Tool Steel Guide
New 70-page brochure includes information on 50 types of tool steels and cold finishing products. *Vanadium-Alloys Steel*

1393. Tool Steels
Bulletin on tool steels, hot work specialty steels, bar stock, billet, sand casting, drill rod, flat ground stock and tool bits. *Darwin & Milner, Inc.*

1394. Tubing
Bulletin on small tubing of stainless, nickel and nickel alloys. *J. Bishop & Co., Platinum Works*

1395. Tungsten Alloy
20-page booklet on machinable tungsten-copper-nickel alloy lists properties, manufacturing and finishing. *Fansteel Metallurgical Corp.*

1396. Ultra Strength Steel
Results of three year research and test program evaluating properties of Type 4340 steel for aircraft structures. *International Nickel*

1397. Vacuum Equipment
Data on high vacuum equipment for vacuum fusion, vacuum melting and casting. *American Electro Metal Corp.*

1398. Vacuum Melting
8-page bulletin on production and testing equipment for vacuum melting. Advantage. *Utica Metals Div., Utica Drop Forge & Tool*

1399. Vacuum Metallizing
Bulletin on equipment for industrial vacuum metallizing. *Optical Film Engineering*

1400. Vacuum Metallurgy
Articles on commercial vacuum furnaces for metals and alloys and some aspects of vacuum melted metals. *National Research*

1401. Vacuum Pumps
New 52-page catalog No. 425 on high vacuum pumps contains formulas and tabular data. *Kinney Mfg.*

1402. Vanadium Products
12-page brochure on 25 steel, iron, aluminum and chemical products. Composition and applications. *Vanadium Corp.*

1403. Waste Treatment
16-page booklet on instrumentation for control of cyanide and chrome waste treatment processes. *Fischer & Porter*

1404. Waste Treatment
4-page folder on pH control in plant waste disposal systems. *Leeds & Northrup*

1405. Welding Electrodes
Folder on designations, applications, properties of stainless steel electrodes. *Alloy Rods Co.*

1406. Welding Equipment
Catalog on Cadweld process and arc-welding accessories. *Erico Products*

1407. Welding Magnesium
Various welding processes for magnesium, stress relief and recommended procedures. *Brooks & Perkins*

1408. Welding Stainless
Data card 162 on the welding of stainless tubing and pipe. *Babcock & Wilcox*

1409. Wire Cloth
84-page booklet on applications, meshes, baskets, filters. *Cambridge Wire Cloth*

1410. Wire Straightening
Bulletin 52-C describes precision machine for straightening small wire with extreme accuracy. Applies to round wire 0.007 to 0.125 in. diameter of ferrous or nonferrous metal. *Continental Foundry & Machine*

1411. X-Ray Equipment
Bulletins on No. 2 SPG X-ray detector describe specifications and advantages. *X-Ray Dept., General Electric*

1412. X-Ray Equipment
12-page booklet on 250-kv. constant potential X-ray equipment for internal inspection. Advantages, design features. *Westinghouse Electric*

October, 1955

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1073	1100	1127	1154	1181	1208	1235	1262	1289	1316	1343	1370	1397
1074	1101	1128	1155	1182	1209	1236	1263	1290	1317	1344	1371	1398
1075	1102	1129	1156	1183	1210	1237	1264	1291	1318	1345	1372	1399
1076	1103	1130	1157	1184	1211	1238	1265	1292	1319	1346	1373	1400
1077	1104	1131	1158	1185	1212	1239	1266	1293	1320	1347	1374	1401
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1080	1107	1134	1161	1188	1215	1242	1269	1296	1323	1350	1377	1404
1081	1108	1135	1162	1189	1216	1243	1270	1297	1324	1351	1378	1405
1082	1109	1136	1163	1190	1217	1244	1271	1298	1325	1352	1379	1406
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1086	1113	1140	1167	1194	1221	1248	1275	1302	1329	1356	1383	1410
1087	1114	1141	1168	1195	1222	1249	1276	1303	1330	1357	1384	1411
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1089	1116	1143	1170	1197	1224	1251	1278	1305	1332	1359	1386	
1090	1117	1144	1171	1198	1225	1252	1279	1306	1333	1360	1387	
1091	1118	1145	1172	1199	1226	1253	1280	1307	1334	1361	1388	
1092	1119	1146	1173	1200	1227	1254	1281	1308	1335	1362	1389	
1093	1120	1147	1174	1201	1228	1255	1282	1309	1336	1363	1390	
1094	1121	1148	1175	1202	1229	1256	1283	1310	1337	1364	1391	
1095	1122	1149	1176	1203	1230	1257	1284	1311	1338	1365	1392	
1096	1123	1150	1177	1204	1231	1258	1285	1312	1339	1366	1393	
1097	1124	1151	1178	1205	1232	1259	1286	1313	1340	1367	1394	
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METAL PROGRESS,

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Postcard must be mailed prior to Jan. 1, 1956
Students should write direct to manufacturers.

5/8" Bar Stock sheared with LUDLUM 609 BLADES



Customer reports shear blades withstand severe shock of Heavy Duty Job without bending or breaking!

A Birmingham manufacturer finds that Ludlum 609 blades take the tough job of shearing 5/8 bar stock in stride. A high elastic limit and fair ductility at comparatively high degrees of hardness give these silico-manganese steel blades the ability to withstand heavy shock without bending or breaking.

Besides superior shock resistance, Ludlum 609 has the advantages of excellent hardenability in larger sections combined with a fine grain size. Characteristics like these make A-L's Ludlum 609 particularly suitable for tools that must withstand severe service. Such applications include shear blades, pneumatic tools, heavy duty punches, shanks for carbide tools, and machine parts exposed to severe shocks.

For the finest in tool steels and technical assistance to help solve your tool or die steel problems, call your A-L representative or distributor today . . . or write *Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pa.*



Write for copy of
CUTTING TOOL MATERIALS

This 36-page illustrated booklet analyzes and compares types and covers grade selection for all major classes of cutting tools, etc., invaluable data for production men. *Ask for your copy today.*

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For complete **MODERN** Tooling, call

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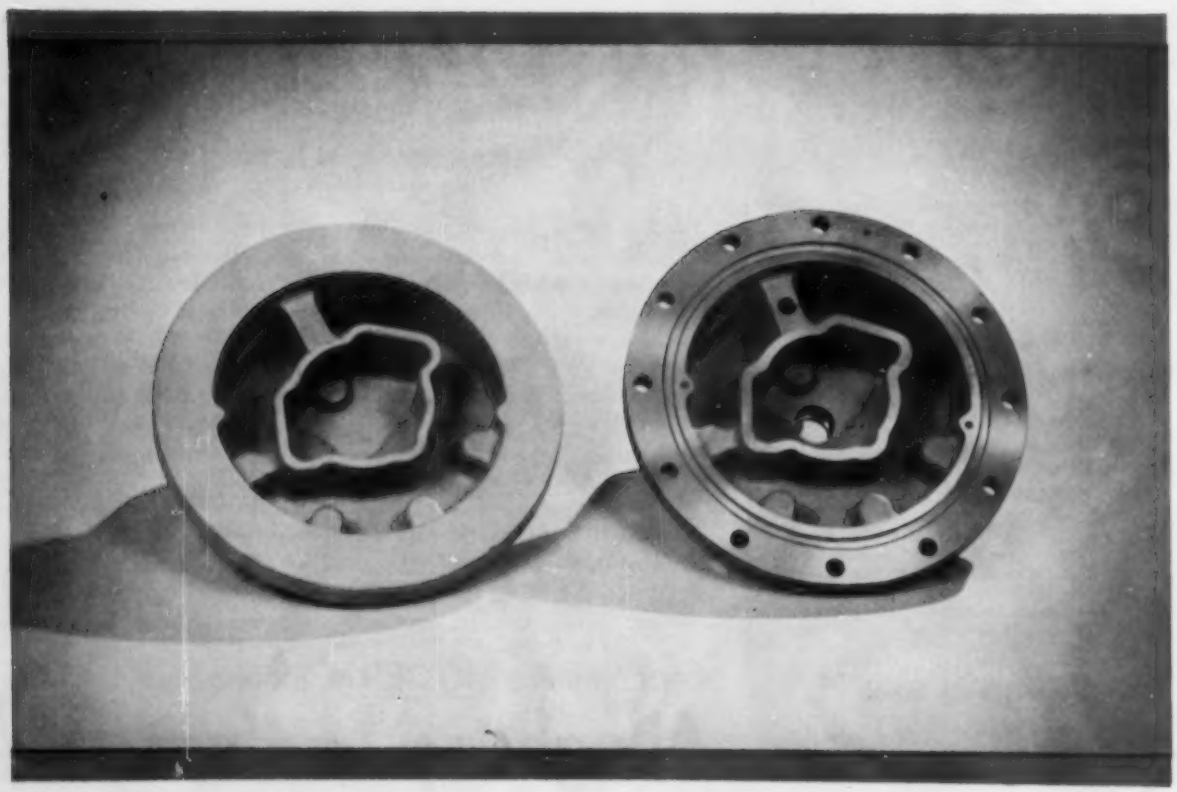
AL
FINE TOOL STEELS SINCE 1854

How shell castings + ArmaSteel

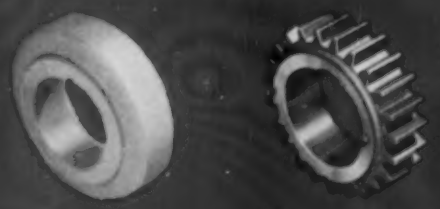
This compressor head casting for an air conditioning unit produced by Central Foundry Division is a good example of the improvements and savings so often realized when ArmaSteel and shell castings are combined. This part is subjected to high chamber pressures and must be free of vapor leaks. ArmaSteel has the ideal physical properties for this job including good machinability.

The shell casting process supplies clean, sand-free casting surfaces and greater dimensional uniformity which eliminates costly machining in the chamber, on the O.D. and profile milling on the contour. Thus, by using the shell casting process together with ArmaSteel in this part, material is saved, machining is saved, scrap losses are reduced 80%, and . . . due to ArmaSteel's high physical properties . . . a greatly improved product results.

Visit our exhibit at Booth No. 945 at the National Metal Exposition in Philadelphia at Convention Hall October 17-21, 1955

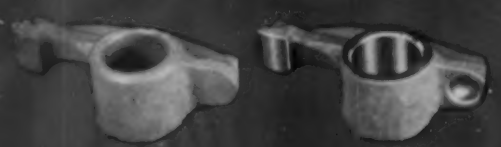


= savings for you



Here are two more parts improved by shell casting. The Crankshaft Sprocket was formerly machined from bar stock on automatic screw machines. By the use of shell castings on automatic chucking machines, material and machining were saved and a product with greater performance resulted.

Rocker Arms are a typical example where the uniformity of shell castings has made the part more adaptable to automatic machining. Preliminary grinding on pad ends has been eliminated, leaving only a finish grind. Center hole is cast with a minimum of finish stock eliminating a preliminary drilling operation.



In **SHELL CASTING** the mold is formed by a thin shell of sand bonded by a thermo-setting plastic. This shell has a hard, smooth surface as accurate as the pattern itself. Shell casting has many advantages:

- **Greater uniformity**
- **Closer tolerances . . . reduced finish allowances**
- **Greater accuracy which makes intricate designs possible**
- **Improved casting surfaces**
- **Freedom from residual sand**
- **Less excess metal resulting in lower freight charges**
- **Longer tool life**

ARMASTEEL is an arrested malleable iron of pearlitic structure. The size and arrangement of carbon nodules in this pearlite result in a freely machining material that has the strength and performance characteristics usually associated with carbon steel forgings. Thus ArmaSteel offers you:

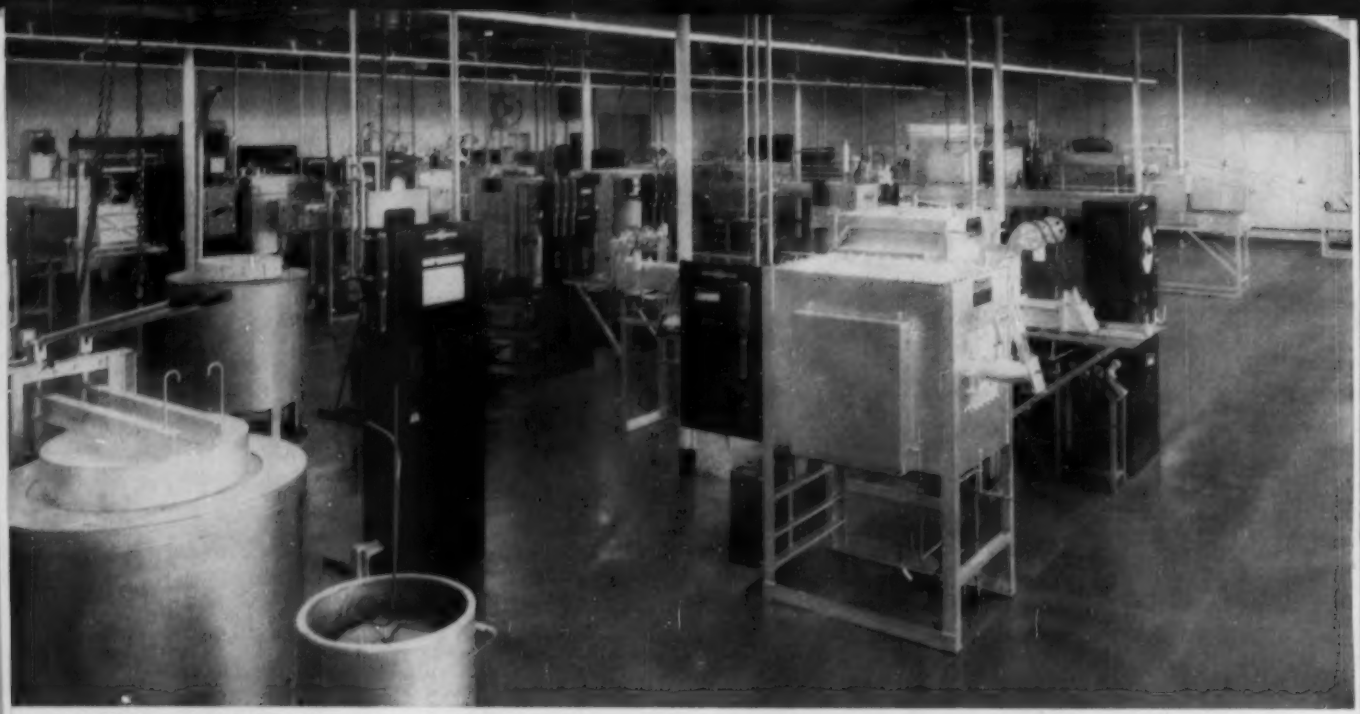
- **Uniform structure**
- **Good machinability**
- **Excellent bearing properties**
- **Good wear resistance under heavy loads at high speeds**
- **Long fatigue life, high yield strength, maximum rigidity**
- **Good damping capacity**
- **Adaptability to selective hardening**

For further information about shell or sand castings, ArmaSteel, malleable iron or grey iron castings, write for descriptive literature . . . or request personal help from our experienced engineers, without obligation.

CENTRAL FOUNDRY DIVISION

GENERAL MOTORS CORPORATION

SAGINAW, MICHIGAN • DEPT. 19



HUNDREDS OF CRITICAL HEAT-TREATING PROBLEMS

The Hayes lab is for

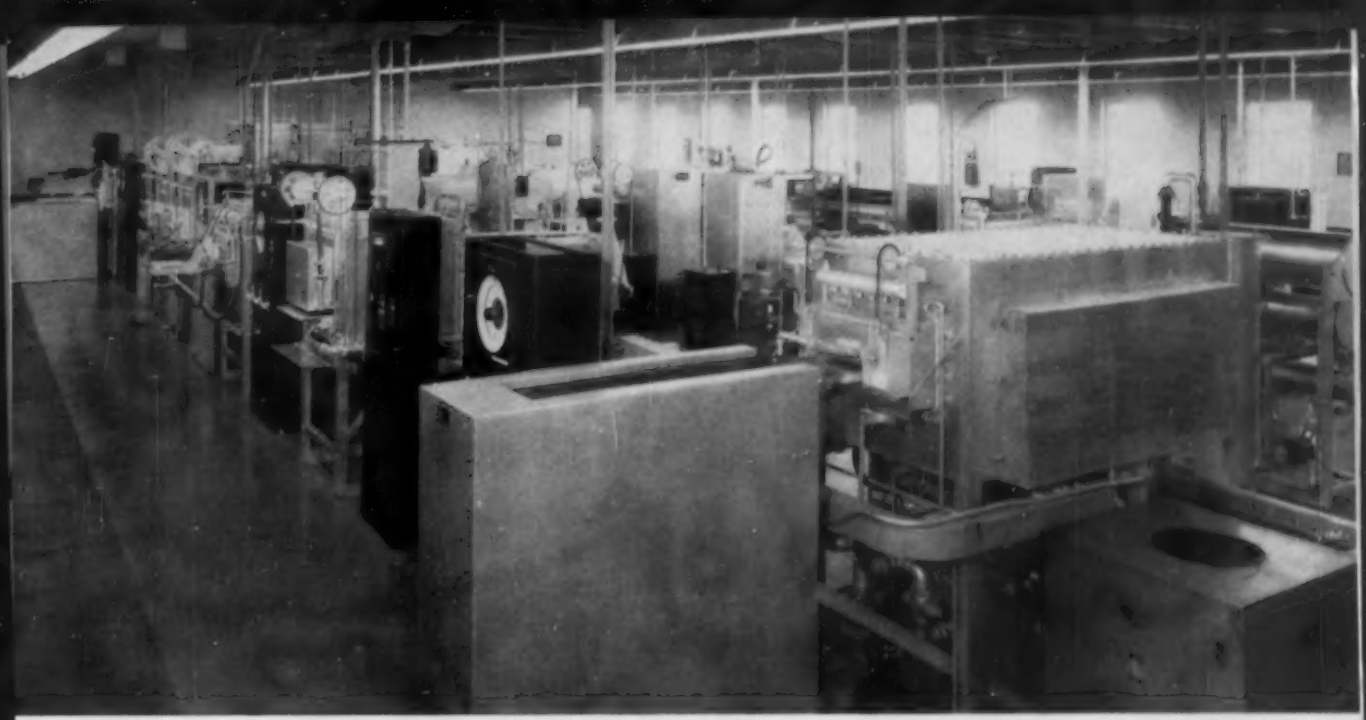
We believe the customer should know, before buying, exactly the results he is going to get.

Bring your work and see it done. Then you'll know.



Hayes Lab Staff offers you the most important concentration of heat-treating know-how to be found anywhere . . . culmination of 50 years of pioneering in electric heat-treating-equipment . . . including introduction of the first controlled-atmosphere furnaces nearly 30 years ago.

See HAYES equipment at Booth No. 1671, at the '55 METALS SHOW



HAVE BEEN SOLVED IN THE HAYES LABORATORY

YOUR protection!

THE MODERN HAYES PLANT





One of two 360-foot straight-through assembly floors, with materials and sub-assemblies feeding in from the sides.

HOME OF CERTAIN-CURTAIN **ELECTRIC FURNACES FOR:**

Annealing & Normalizing
Brazing & Soldering
Carbo-nitriding & Carburizing
Drawing & Tempering
Enameling
Forging
Glass Treating & Sealing
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Stainless Steel Bright Heat Treatment

Plus exclusive advanced types of
Atmosphere Generators and Ammonia Dissociators

GOLDEN 50 ANNIVERSARY

C. I. HAYES INC. 887 WELLINGTON AVE., CRANSTON 10, R. I.

New "A" Model Ipsen

50% GREATER LOAD CAPACITY

50% GREATER HEATING RATE

50% GREATER QUENCH CAPACITY



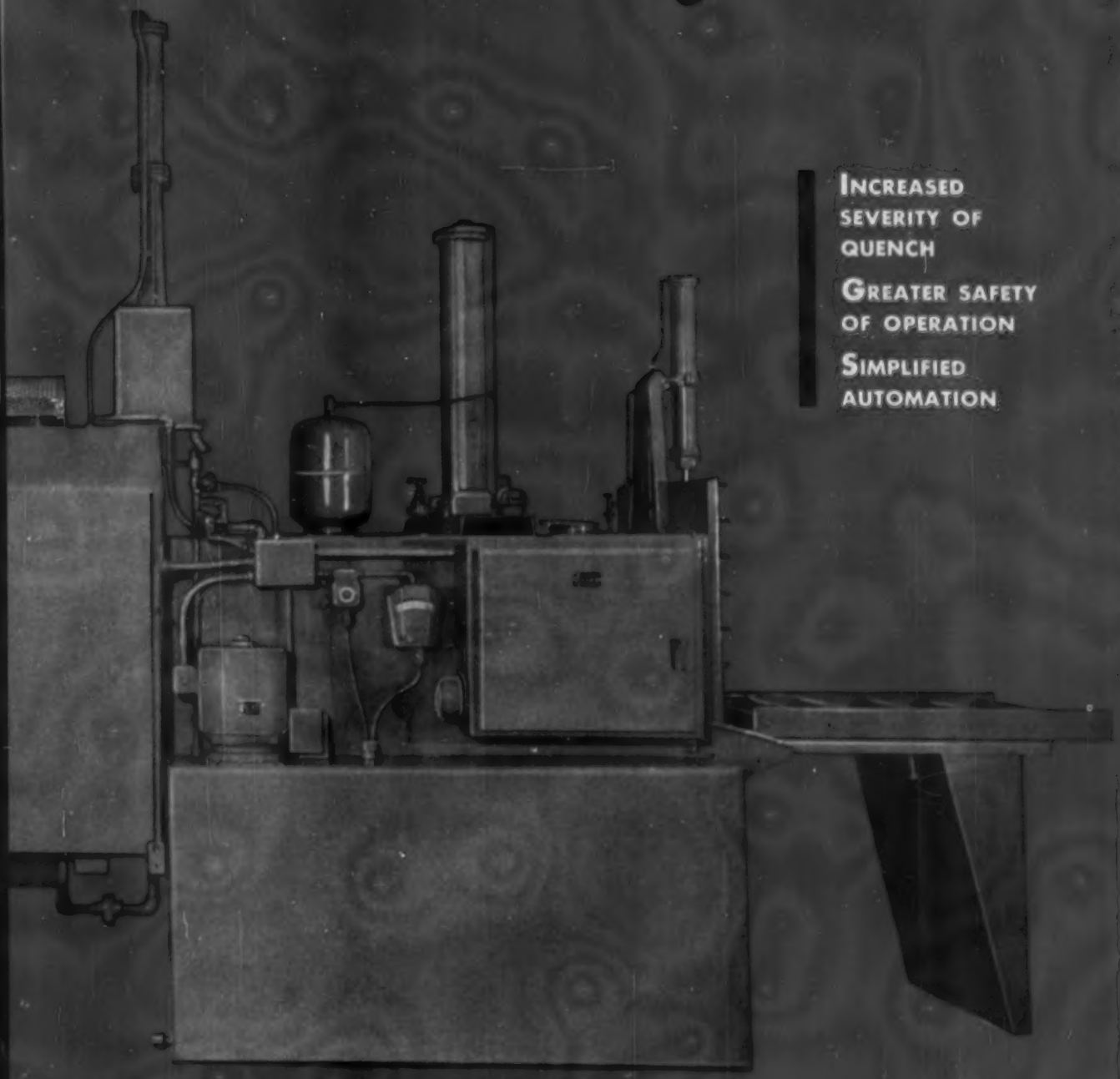
NOW . . . MAXIMUM LOADS AT ALL TEMPERATURES

NEW RADIANT TUBES NOT AFFECTED BY TEMPERATURE

IMPROVED 100% FORCED CONVECTION HEATING

FULL DETAILS AT THE METAL SHOW . . . BOOTH 420

Heat Treating Units



INCREASED SEVERITY OF QUENCH

GREATER SAFETY OF OPERATION

SIMPLIFIED AUTOMATION

AUTOMATIC Ipsen HEAT TREATING UNITS

IPSEN INDUSTRIES, INC., 723 S. Main St., Rockford, Ill.



Controlled Atmosphere Heat Treating Units



Controlled Atmosphere Tempering Units



Automatic Washers



Drawouts and Carburizing Generators



Atmosphere Generators

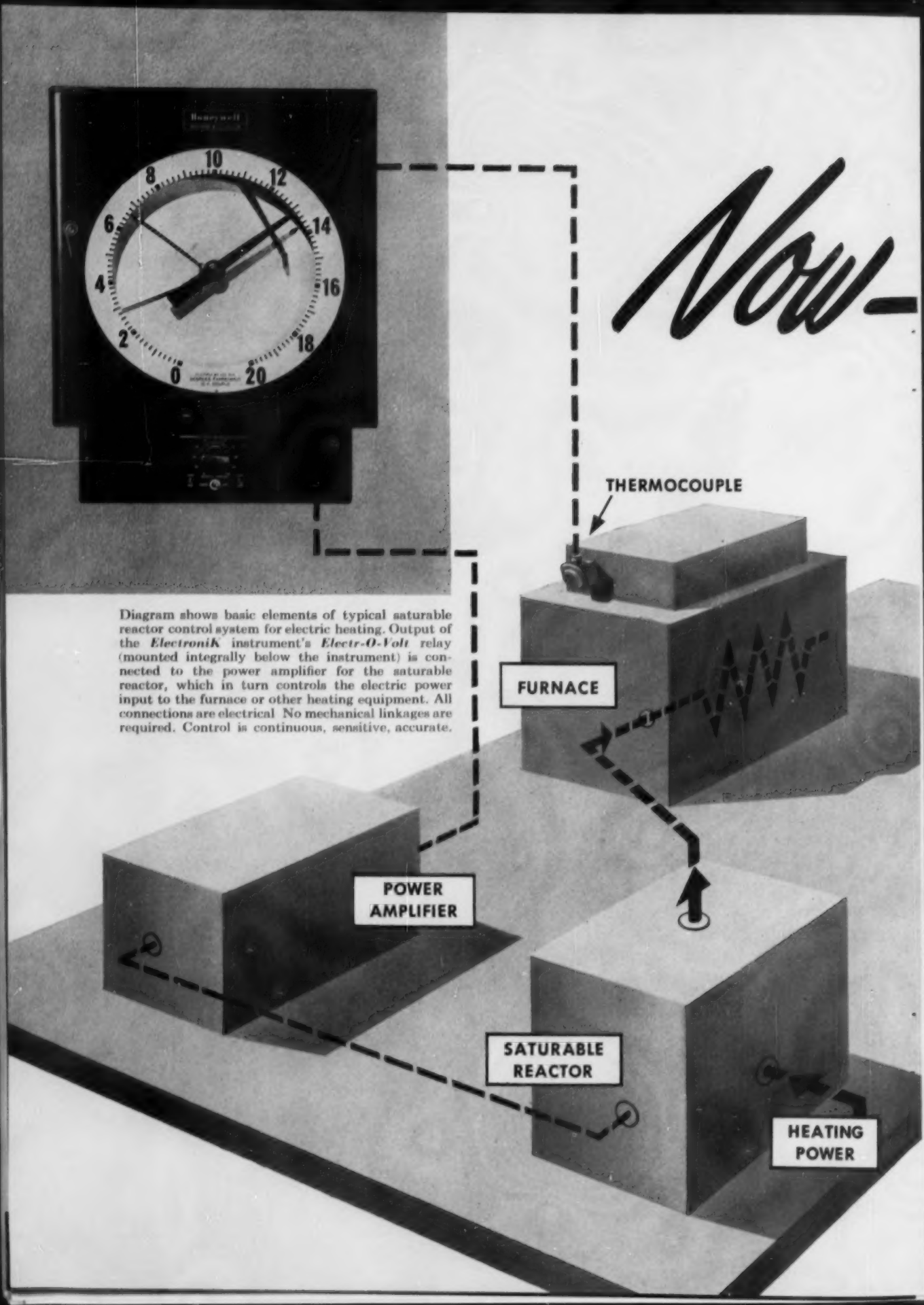


Diagram shows basic elements of typical saturable reactor control system for electric heating. Output of the *ElectroniK* instrument's *Electr-O-Volt* relay (mounted integrally below the instrument) is connected to the power amplifier for the saturable reactor, which in turn controls the electric power input to the furnace or other heating equipment. All connections are electrical No mechanical linkages are required. Control is continuous, sensitive, accurate.

continuous, accurate control of electrically heated equipment

ElectroniK instrumentation with Electr-O-Volt* relay provides continuous throttling in saturable reactor control systems

You can now regulate temperatures of electrically heated furnaces, ovens, and similar processing equipment within exceptionally close tolerances, by using an advanced *ElectroniK* control system in conjunction with saturable reactors. This type of control eliminates the abrupt surges of power and the expense of contact replacement which are frequently objectionable factors of on-off or pulsed electric control.

Continuous control action. The *Electr-O-Volt* relay, actuated by the *ElectroniK* instrument, provides continuously variable control input to the saturable reactor power amplifier. This arrangement gives true proportional-plus-reset control action, which adjusts heat input to compensate for size of load, ambient temperature and other transient and long-term variations in heat demand.

Completely electronic. The system has no mechanical linkages, contactors, or other complex moving parts. Its high speed and sensitivity give the precise control required by modern processes.

Broad range of use. *ElectroniK* control for saturable reactors is applicable to high-temperature heat-treating furnaces, reaction vessels and many other types of electrically heated equipment. It makes possible smooth, finely-adjusted regulation of electric power at high efficiency.

For a discussion of how this control can be applied to your specific problems, call your local Honeywell sales engineer. He's as near as your phone.

Minneapolis-Honeywell Regulator Co., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario. *Trademark

● **REFERENCE DATA:** Write for Catalog 1531, "*ElectroniK* Controllers," and for new Bulletin 8420, "*Electr-O-Volt* Relay."

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

First in Controls



Stokes vacuum brazing furnace at Pratt & Whitney Aircraft offers complete accessibility to work area and simplicity in material handling. These three simple operations are involved: (1) placing of work (2) covering work with retort and (3) lowering the furnace shell.

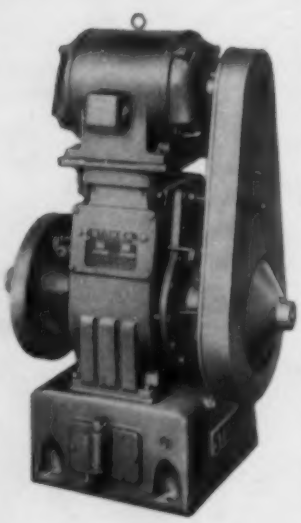
Pratt & Whitney



THE COMPLETE LINE OF STOKES

Stokes manufactures a complete line of vacuum pumping equipment. This includes mechanical vacuum pumps, diffusion and booster pumps, vacuum valves and gages, and complete vacuum instrumentation. In engineered high vacuum equipment, Stokes builds vacuum metallizers, vacuum furnaces and other vacuum processing equipment.

Stokes has for many years been active in vacuum research. Vacuum experience among our engineers covers the range from laboratory equipment to some of the largest vacuum equipment in service. This experience is available to help solve your vacuum problems.



STOKES MECHANICAL VACUUM PUMPS

For vacuum processing systems and for maintaining low forepressures in high-vacuum systems, the Stokes Microvac pump provides efficient, economical operation. Designed with fully automatic lubrication and a long-lasting exhaust valve assembly, every Microvac pump is assured of smooth, trouble-free operation. Six sizes give capacities from 15 to 500 cfm. Send for catalog listed at right.

Aircraft Uses Stokes Furnace to Investigate Vacuum-Brazing of Jet Engine Components

Versatile new furnace design also can be used for heat-treating and outgassing at high vacuum or under controlled atmospheres.

A logical development of vacuum metallurgy, high-vacuum brazing, presently being investigated by numerous firms throughout the country, promises to produce superior products more economically than brazing methods used heretofore. Tests of vacuum brazed components indicate the greater strength, ductility and uniformity of assemblies produced by this method.

Typical of firms currently carrying on investigations in this field is Pratt & Whitney Aircraft, East Hartford, Conn. The firm is using a Stokes furnace in experimental work on the application of vacuum brazing to the production of jet engine components.

Stokes' furnace design for vacuum brazing is practical . . takes into account the problems of large-scale production. The Stokes dual-chamber design, with a smooth-contour retort completely enclosing the work, permits faster vacuum pumping cycles; provides complete accessibility of the work area and a large, uniform temperature zone.

Stokes engineers have a wealth of practical experience in the field of vacuum metallurgy. We'll be glad to discuss the application of this fast-growing science to your production. Write for Catalog 790 containing valuable information on Stokes High-Vacuum Furnaces.

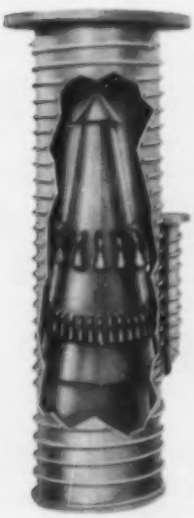
F J Stokes Machine Company, 5504 Tabor Road, Philadelphia 20, Pa.

SEND FOR TECHNICAL LITERATURE:

- Microvac Pumps—Catalog 750
- Diffusion and Booster Pump Specification sheets and performance curves
- The Story of the Ring-Jet Pump
- Complete Vacuum Processing Systems—Catalog 730
- How to Care for Your Vacuum Pump—Booklet 755
- Vacuum Impregnation—Catalog 760
- Vacuum Drying—Catalog 720
- Vacuum Furnaces—Catalog 790
- Vacuum Metallizing—Catalog 780
- Vacuum Calculator Slide Rule



VACUUM EQUIPMENT



STOKES RING-JET DIFFUSION AND BOOSTER PUMPS

The new Stokes Ring-Jet Pumps embody a new concept of the diffusion principle. Size for size, they have pumping speeds of 10% to more than 100% above any other diffusion pump for a given heat input. Ring-Jet Diffusion Pumps are available in sizes of 4, 6, 10, 14 and 16 inches; Booster Pumps in sizes of 4, 6, 10 and 16 inches. Send for information listed.

STOKES VACUUM VALVES

To control vacuum safely and surely, Stokes vacuum valves are available in 4, 6, 10 and 16-inch standard flange sizes.

STOKES-McLEOD VACUUM GAGES

For measuring vacuums from fractions of a micron up to 50 mm, Stokes-McLeod gages are the standard of reference. Four sizes available.

STOKES

OFFICES IN PRINCIPAL CITIES, REPRESENTATIVES THROUGHOUT THE WORLD

Fittings stay fastened in Corrosive Acid Spray



PROBLEM:

Selecting fastenings that would hold pipe fittings together in a unit that is constantly subjected to a hot sulphuric acid spray. Bolts were formerly falling apart in four months' time.

REMEDY:

Use of nuts and bolts made of wrought HASTELLOY alloy C.

RESULT:

Fastenings made of HASTELLOY alloy C are still holding many months after ordinary bolts had to be replaced.

HASTELLOY alloy C is the most universally corrosion-resistant alloy available today. In addition to aerated sulphuric acid, it has excellent resistance to such strong oxidizers as nitric acid, wet and dry chlorine, and acid solutions of salts. It is available in nearly all standard commercial forms.

For more information on HASTELLOY alloy C, get in touch with the nearest Haynes Stellite Company Office.

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HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

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"Our Formula for Successful Quenching"

SAYS RAGAN RING CO., ATLANTA, GEORGIA

Out of the Furnace...





...into SINCLAIR QUENCHOL 521

Ragan Textile Rings must be uniformly hard, completely free of flaws and must have the smoothest finish obtainable.

To get these results from cold drawn seamless tubing, Ragan Ring Co. uses Sinclair QUENCHOL 521.

Ragan Ring says, "When, for economical reasons, we installed our own heat treating furnaces and were looking for one of the best quenching oils on the market to heat treat our top quality rings, we naturally looked to the man in whom we had absolute confidence – our Sinclair Engineer. He recommended QUENCHOL 521 and gave us a demonstration of what it would do. We put our new system into operation with QUENCHOL 521 in the tank.

"We are getting even better results than before – more uniform hardness, and no signs of flaws."

For a demonstration of this revolutionary new quenching oil, call your local Sinclair Representative, or write for a new booklet about QUENCHOL 521 to the Sinclair Refining Company, Technical Service Division, 600 Fifth Avenue, New York 20, N.Y.

SINCLAIR CUTTING OILS and COOLANTS



TITANIUM STRIP is descaled continuously on time cycles as low as 30 seconds, with excellent results.



10-MINUTE IMMERSION loosens scale on 5 tons of stainless wire. A water quench, 3-minute acid dip, and final water rinse produce a clean, bright surface with no pitting or etching.

Use this fast, safe Hooker Process for descaling steel and titanium

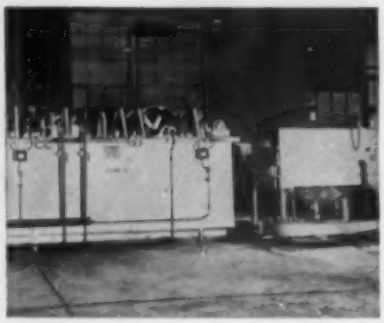
Descale alloy steels and titanium in any form—rapidly, safely—using the Hooker Process with Virgo® Descaling Salt.

A bath of molten Virgo Descaling Salt quickly converts scale, rust, and other surface impurities to an acid-soluble coating. A quench, acid dip, and final spraying then remove this coating in from one-tenth to one-hundredth the usual pickling time, with no measurable effect on the base metal.

You can easily set up the Hooker Process for batch or continuous operation on any form of work including strip, sheets, bars, wire, tubes, plate, castings, forgings, and fabricated parts. You can usually process work as fast as your handling methods allow, with a minimum of supervision. Operation is safe for personnel, and there is little or no spent-acid disposal problem.

You can profit by the experience of more than 50 companies now using the Hooker Process successfully to speed up descaling of alloy steels and titanium in practically every form.

You'll get quick service on any descaling problem, by writing or phoning us. Complete test and engineering facilities are at your disposal, without obligation.



LIGHT-GAUGE ALLOY STRIP is descaled at 20-35 ft. per min. in this Virgo bath, after annealing.



Send for these bulletins—Get the whole story on Virgo Descaling Salt for alloy steels and titanium . . . how the Hooker Process works, its advantages, how to set up a Virgo descaling line, and the services you enjoy as a user. No obligation. Write us today.

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From the Salt of the Earth—1955

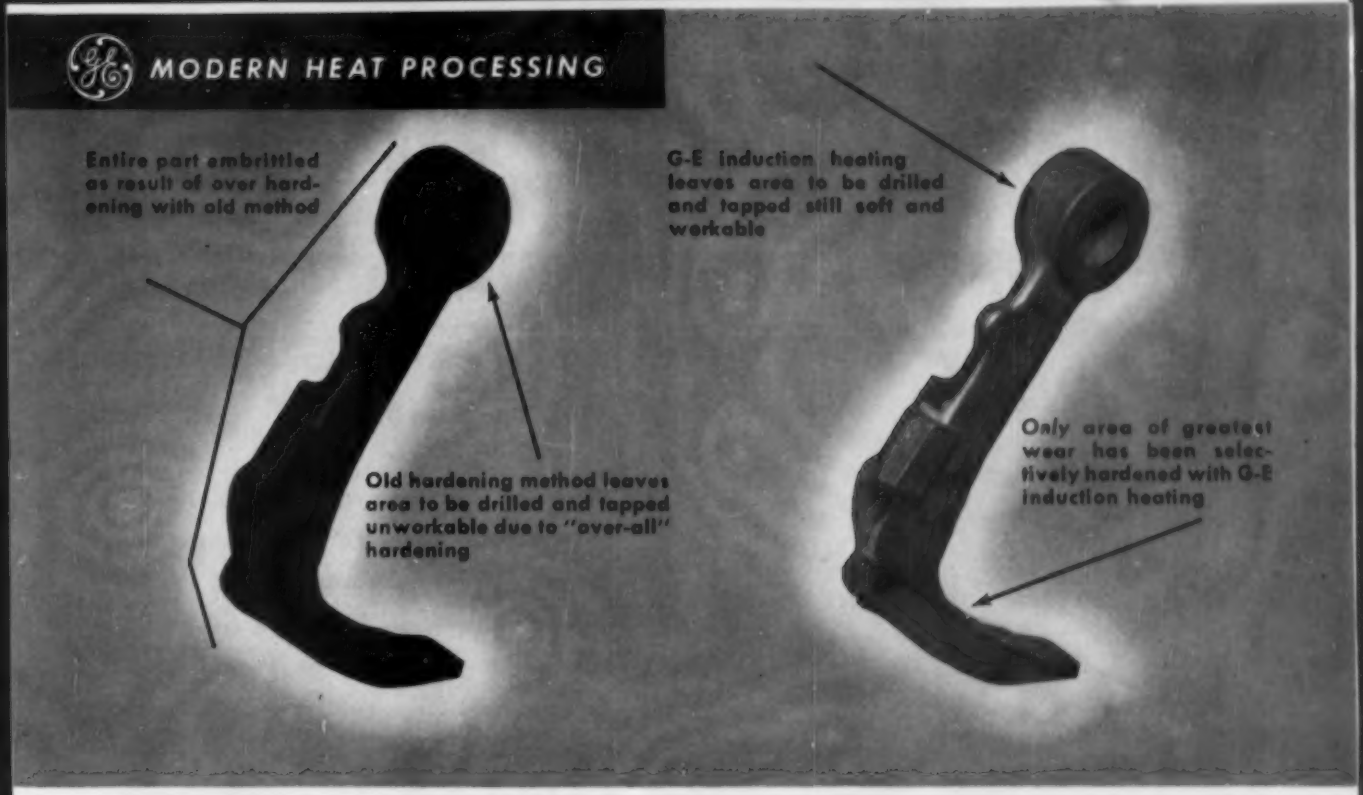
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MODERN HEAT PROCESSING



PROBLEM:

Chill-cast rejects at Draper Corporation due to (1) Embrittlement (2) Over-all hardening

SOLUTION:

G-E Induction Heater Cuts Rejects 95% By Pinpoint Hardening Cast-iron Parts

The East Spartanburg, S. C. division of Draper Corporation was having difficulty controlling the hardening of cast-iron parts. Their old chill-cast hardening method forced them to reject many of the parts, which were overhardened and brittle. In addition, they had no way of controlling the size of the area to be hardened. This made drilling and tapping operations difficult—and frequently impossible.

SINCE INSTALLING A 20-KW G-E induction heater in their production line, they are able to cast the parts, drill and tap them while the cast iron is still soft, and then selectively harden only the area of greatest wear. This "pinpoint" hardening reduces the heated area of the parts by 70–90%. As a result, rejects have been cut 95%, costs are reduced, and the Draper Corporation is producing a product of uniform high quality.

THE COMPLETE SATISFACTION of Draper Corporation with their General Electric induction heating equipment was expressed by Mr. Fred Burgess, Plant Engineer: "Our G-E induction heater has been in operation for over five years. During that time we have greatly reduced manufacturing costs because of our decreased scrap losses and increased production. Maintenance of the heater hasn't been any problem, either. We just couldn't ask for any better service than we've had from our G-E equipment."

GENERAL ELECTRIC

WATCH FOR ANNOUNCEMENT

of General Electric's complete NEW line of electronic induction heaters

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For application assistance, contact your nearest G-E Apparatus Sales Office or send coupon for free bulletin GEA-4945.

General Electric Company
Apparatus Sales Division, Section E722-2
Schenectady 5, New York

Name.....

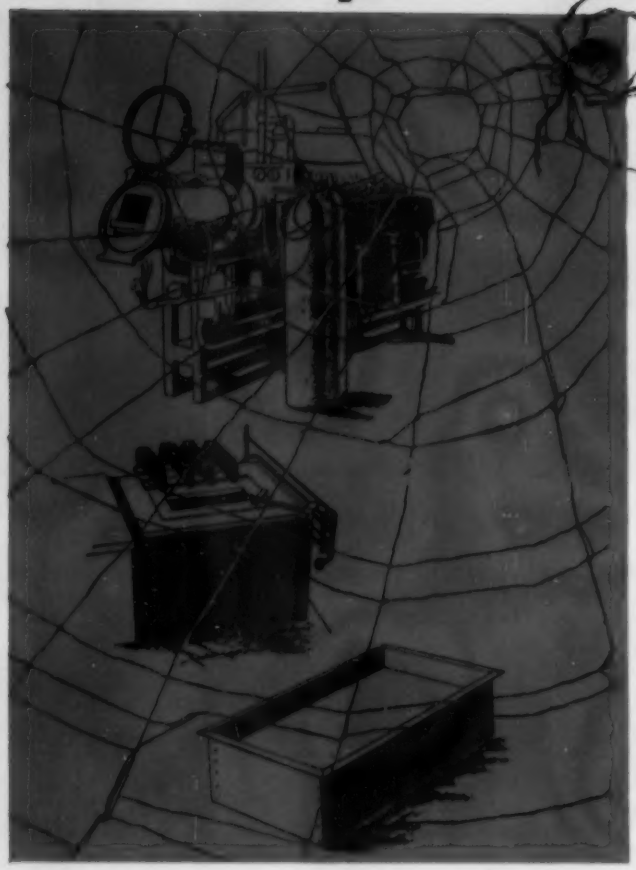
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Company.....

City..... **State**.....

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When reduced production schedules result in part time operation of your heat treating facilities, overhead burden rapidly rises to a point of no return. Chances are there is a local commercial organization which, because of the nature of his service business, is geared to handle your reduced volume and eliminate your heat treating department's red ink.

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Allied Metal Treating Corp.
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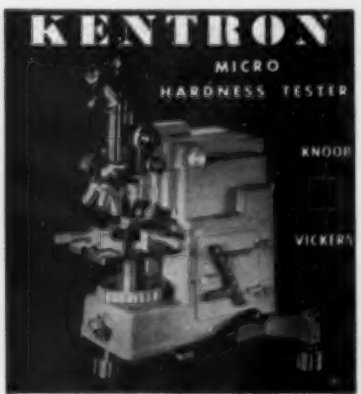
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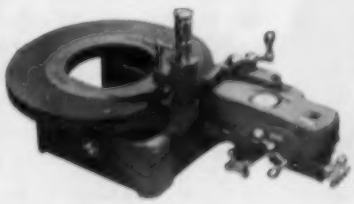
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with the TABER DIHEDRON

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SOLVED with

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Electronic Equipment for non-destructive production inspection of steel bars, wire rod, and tubing for mechanical faults, variations in composition and physical properties. Average inspection speed 120 ft. per minute.

Over 50 steel mills and fabricators are now using this equipment.

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for rapid, accurate non-destructive THICKNESS MEASUREMENTS from one side

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AUTOMATIC THICKNESS GAGE

21" Cathode-Ray Tube;
Direct-Reading Scales;
Any Range between 0.005" and 2.5";
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Cables up to 1000 feet for remote testing.

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Outputs from 100 Watts to 25 KW.

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Unscrambles Metal Mixups



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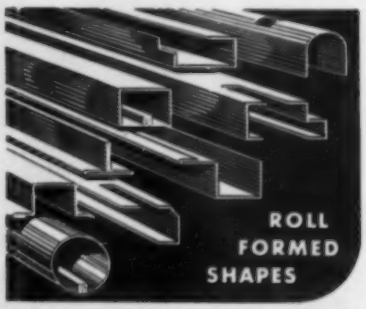
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This instrument permits truly high speed, non-destructive sorting of raw, semi-finished or finished parts by their metallurgical characteristics. Several thousand parts per day can ordinarily be sorted by this manual method. For regular production sorting get details on our Model CER. Used by leading industrial firms everywhere.

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Reduce your assembly problems and costs. Our shapes continuously formed, with high degree of accuracy, from ferrous or non-ferrous metals. Write for Catalog No. 1053.

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Soluble Gold

For Industrial and Decorative Electroplating

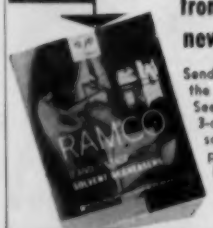
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of any size and shape —
any ductile metal

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WIRE PRODUCTS SINCE – 1880

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SAVES EXCESSIVE HANDLING TIME REQUIRED BY HEATED PHOSPHATE PROCESSES.

Phospray minimizes cleaning and eliminates rinsing and drying.

Phospray dries "dust free" immediately, ready for application of final finish.

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Phospray cuts processing time, reduces finishing costs, and provides an easy sure-fire bond for organic finishes on almost any metal.

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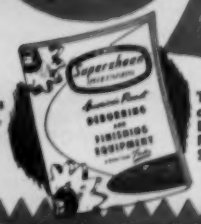
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For efficient metal cleaning

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For certain rust prevention

USE SWIFT RUST PREVENTATIVES!

For heat treating

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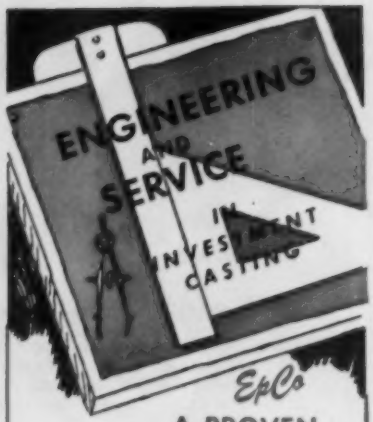
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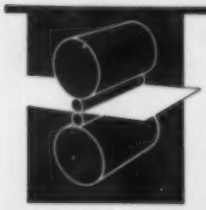
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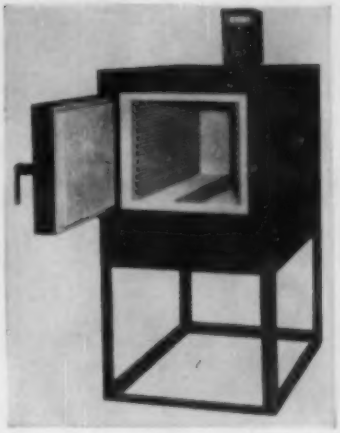


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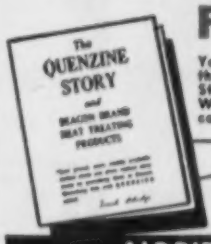
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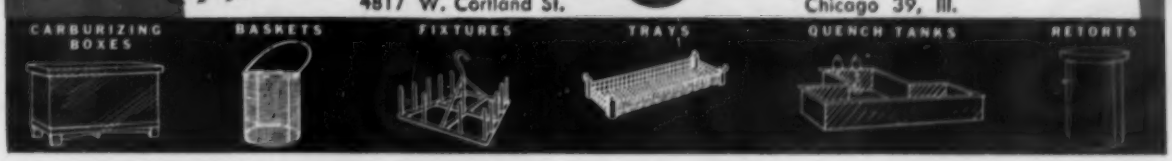
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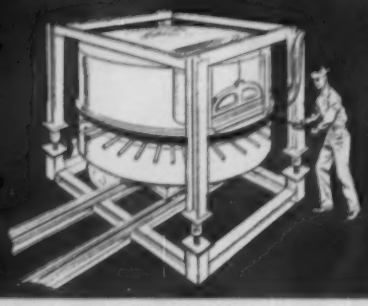
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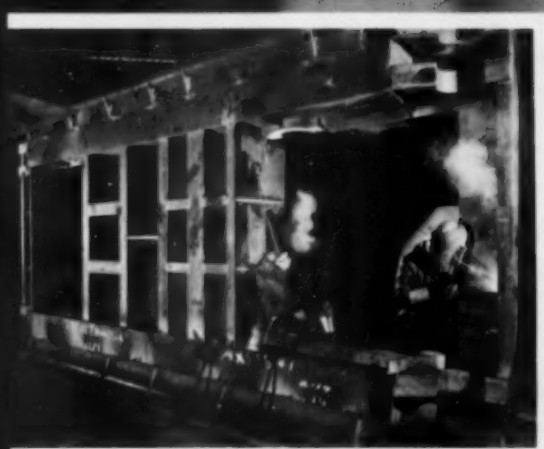
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50-ton crane becomes 85-ton crane

with no increase in size



United States Steel's Edgar Thomson Works in Braddock, Pennsylvania, needed new and heftier crane equipment to handle larger ladles. One requirement was four new crane trolleys which were to operate on the same bridges, if possible, and in exactly the same clearances as before.

The trolleys had to be stronger but no larger than before; so ordinary steel wouldn't do. Needed, was a steel of *exceptional strength* which could be *welded easily*. Lots of alloy steels could have met the strength requirements; but USS "T-1" Steel was the *only* steel that could supply not only the required strength, but good weldability as well.

"T-1" Steel plate—in ¾" and 1" thicknesses—was used in box girders and lateral stiffener plates of the trolleys. This change increased the crane capacity from 50 to 85 tons with no increase in size.

The structure was welded with AWS E12015 electrodes. It was as easy as welding carbon steel. No stress relief was needed. And the welds developed the full yield strength of the steel: 90,000 psi. minimum.

Remember this story when you must weld very high strength parts—parts that must operate at temperatures as high as 900°F. or as low as 40°F. below zero, parts that must withstand tremendous impact abuse, abrasion or tensile stress. Then consider USS "T-1" Constructional Alloy Steel. For full particulars write: United States Steel, Room 4968, Pittsburgh 30, Pa.

UNITED STATES STEEL CORPORATION, PITTSBURGH · COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
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USS "T" CONSTRUCTIONAL ALLOY STEEL

USS

UNITED STATES STEEL

"Forgings stay straight as an arrow in these furnaces"

says
Clair J. Koehler,
U. S. Steel Heater



OUR HOMESTEAD FORGINGS DIVISION has the most modern heat treating facilities available to accommodate the most critical forging specifications.

These vertical furnaces, for example.

These furnaces permit the ultimate in temperature control and completely eliminate any possibility of distortion even when heating forgings, such as the turbine rotor shown, to temperatures as high as 1830°F!

Why did we install these furnaces?

Clair Koehler, a heater for 15 of his 31 years with us, can answer. "Large shafts stay straight as an arrow in these verticals. We get better temperature control, too. Total temperature variation is less than 10°F. from top to bottom."

Such laboratory-type precautions are typical of the care all forgings receive at United States Steel.

Address inquiries or requests for our free 32-page booklet on USS Quality Forgings to United States Steel, Room 4968, 525 William Penn Place, Pittsburgh 30, Pa.

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UNITED STATES STEEL

UNITED STATES STEEL



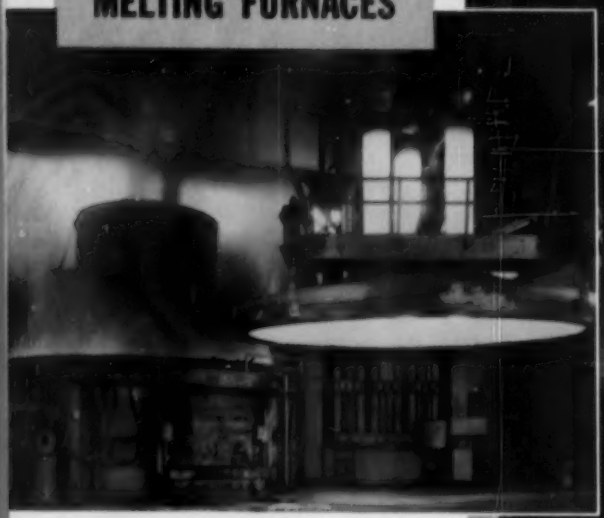
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Quality FORGINGS

- heavy machinery parts—carbon, alloy, stainless
- forged steel rolls and back-up roll sleeves
- electrical and water wheel shafts
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Heroult ELECTRIC MELTING FURNACES

TOPS FOR PRODUCTION OF HIGH GRADE STAINLESS, ALLOY AND RIMMING STEELS





World's Largest Electric Furnaces

. . . now in operation!

INSTALLED in the ultra-modern mill of McLouth Steel Corporation, in Detroit, these giant *200-Ton* Heroults are the largest electric melting furnaces ever built. With an inside shell diameter of 24'6", they have a rated charge capacity of 400,000 pounds, and each is designed for efficient operation on 25,000 to 33,000 KVA transformer capacity. Featuring a swing-type roof, these furnaces are equipped with the finest, most up-to-date mechanism and electrical controls available.

McLouth's adoption of electric furnaces of this size sets a precedent. It is a "first" which should conclusively prove that, in addition to closer control, higher uniformity, better performance, and greater safety, large capacity Heroult Electric Furnaces are an economically sound investment—even for high tonnage steel-making.

We welcome an opportunity to help you select and install the furnace best suited to your particular requirements.

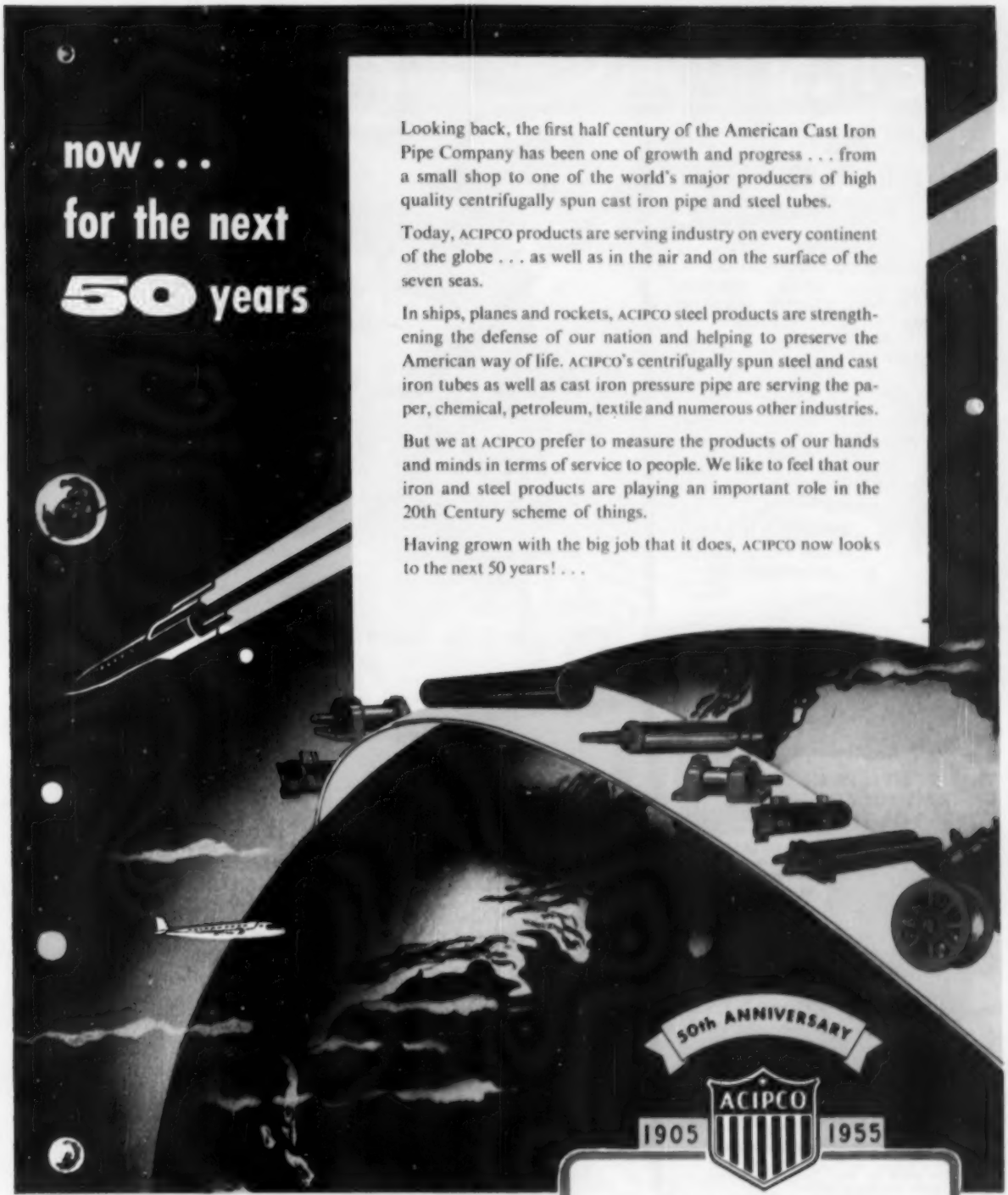
ASK FOR NEW CATALOGUE. *Contains latest information on modern electric furnaces—types, sizes, capacities, rating, etc. Write Pittsburgh Office for free copy.*

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USS

UNITED STATES STEEL



Looking back, the first half century of the American Cast Iron Pipe Company has been one of growth and progress . . . from a small shop to one of the world's major producers of high quality centrifugally spun cast iron pipe and steel tubes.

Today, ACIPCO products are serving industry on every continent of the globe . . . as well as in the air and on the surface of the seven seas.

In ships, planes and rockets, ACIPCO steel products are strengthening the defense of our nation and helping to preserve the American way of life. ACIPCO's centrifugally spun steel and cast iron tubes as well as cast iron pressure pipe are serving the paper, chemical, petroleum, textile and numerous other industries.

But we at ACIPCO prefer to measure the products of our hands and minds in terms of service to people. We like to feel that our iron and steel products are playing an important role in the 20th Century scheme of things.

Having grown with the big job that it does, ACIPCO now looks to the next 50 years! . . .

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ACIPCO

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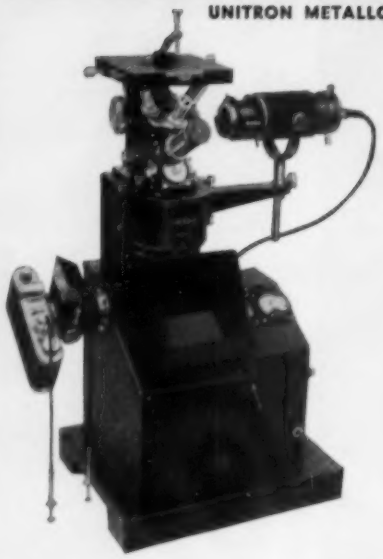
This colorful, illustrated catalog gives complete specifications on all of the instruments briefly described on this page, as well as others which we know will interest you. Send coupon below for your free copy.

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204 Milk Street, Boston 9, Mass.

Please send us your complete catalog on UNITRON Microscopes.

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UNITRON METALLOGRAPH and UNIVERSAL CAMERA



Microscope, New Model U-11

- For visual observation, measurement, and photography of both opaque and transparent specimens.
- Bright field, dark field, and polarized illumination.
- Revolving nosepiece with 5 objective lenses, 4 photographic eyepieces, 3 visual eyepieces. Coated optics. Magnification range: 25-2000X.
- Compact and entirely self-contained with built-in 3¼" x 4¼" camera, high-intensity illuminator, variable transformer. The image is automatically in focus in the camera—transition from observation to photography is instantaneous.
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- Calibrated square mechanical stage with calibrated rotatable stage plate.
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UNITRON Model MMU pioneers several new features available for the first time and, in addition, includes features found only in instruments selling for well over twice our unusually low price. For metals and other opaque specimens under both ordinary and polarized light. This model far surpasses the usual metallurgical microscope in versatility and makes an ideal all-purpose laboratory microscope. Its features include:

- transformer built into microscope base.
- vertical illuminator with iris diaphragm and filters.
- illuminator mounts on stage for oblique lighting.
- illuminator mounts substage for transparent specimens.
- coated optics.
- coarse and fine focusing.
- focusable stage.
- calibrated drawtube.
- polarizing apparatus and 5 filters.
- revolving nosepiece with objectives 5X, 10X, 40X, 100X, oil.
- eyepieces: P5X, P10X, K15X.

COMPLETE, only **$287.**



UNITRON STUDENT MODEL MMA

UNITRON Model MMA is a complete and versatile metallurgical microscope priced at about the usual cost of an accessory vertical illuminator needed to adapt an ordinary microscope for work with opaque specimens. Model MMA offers many of the novel features of the larger Model MMU insofar as these features are not connected with the higher magnifications obtainable with an oil-immersion lens. Its low cost makes the MMA ideal for student use and routine laboratory investigations. Its features include:

- transformer built into microscope base.
- vertical illuminator with iris diaphragm.
- illuminator mounts on stage for oblique lighting.
- illuminator mounts substage for transparent specimens.
- coated optics.
- single focusing control
- substage 5-hole disk diaphragm.
- frosted filter
- revolving nosepiece with objectives 5X, 10X, 40X.
- eyepieces: H5X, P8X, K15X.

COMPLETE only **$149.**



UNITRON Model MEC

is of the inverted type and designed for visual observation of metals, ores, minerals, etc. It includes many of the features of the Model U-11 Metallograph which are connected with visual observation of opaque specimens. 25-1500X.

- transformer built into microscope base.
- vertical illuminator with iris diaphragm.
- coarse and fine focusing.
- filters: polaroid, frosted, blue, green, yellow.
- large mechanical stage with graduated circular rotatable stage plate.
- calibrated polarizing apparatus.
- coated optics
- revolving nosepiece with objectives 5X, 10X, 40X, 100X oil.
- eyepieces: P5X, Micrometer 10X, K15X.

COMPLETE only fob Boston **$319.**

United Scientific Co.
204-206 MILK STREET, BOSTON 9, MASS.



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Thousands of weldments of many shapes, sizes and weights are produced by Mahon every year. Those illustrated here are typical of parts and assemblies produced for manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment. If you require parts or assemblies, including large heavy pieces where time and pattern costs are a consideration, you can turn the job over to Mahon with complete confidence, because Mahon's service to users of welded structural or heavy plate fabrications is complete from design to finished machining and assembling. If you are a buyer of weldments, or welded steel in any form, you, too, will find in the Mahon organization a unique source . . . a source where design skill and advanced fabricating techniques are supplemented by craftsmanship which assures you a smoother, finer appearing job embodying every advantage of Steel-Weld Fabrication. See Sweet's Product Design File for information, or write for Booklet showing Mahon facilities and capabilities to serve you well.

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Engineers and Fabricators of Steel in Any Form for Any Purpose

MAHON

SUN QUENCHING OIL NO. 11 LASTS FOUR TIMES LONGER THAN COSTLY COMPOUNDED OIL

Provides clean bright-quenched parts at lower cost ...keeps tanks and coolers cleaner longer

To get clean, bright-quenched parts, J. W. Rex Company, Lansdale, Pa., one of the foremost heat treaters in the country, had to drain their 1500-gallon quench tank every few weeks. High oil cost and frequent shutdowns for tank and cooler cleaning became too expensive.

A Sun representative made a thorough analysis of this problem. He then suggested a switch to Sun Quenching Oil No. 11—at a price about half that of the costly compounded oil they were using.

Now, *twelve months later*, the original charge of Sun Oil is still in the tank! Make-up is considerably lower...parts are continuing to come out clean and bright...and... tank maintenance costs are practically nil!

To find out how a Sun Quenching Oil can help *you* heat treat metal at lower cost, phone your local Sun representative or write for Sun's latest Technical Bulletin containing complete information about Sun Quenching Oil No. 11. Address SUN OIL COMPANY, Philadelphia 3, Pa. Dpt. MP-10.



J. W. Rex, right, President of J. W. Rex Co. and Sun representative check brightness of an intricate 8620 steel part after quench in Sun Quenching Oil No. 11.

SUNOCO

INDUSTRIAL PRODUCTS DEPARTMENT

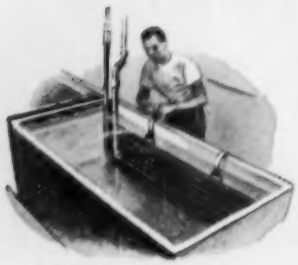
SUN OIL COMPANY

Philadelphia 3, Pa.

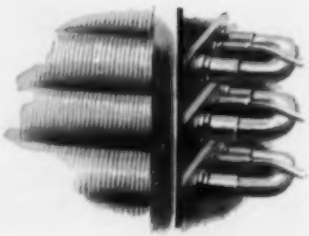
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SUN QUENCHING OIL NO. 11
DRAINS OFF PARTS FAST

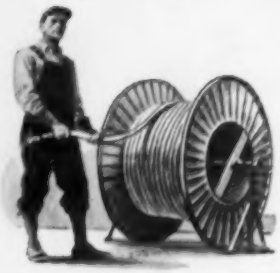
How STRAITS TIN from MALAYA is being used to make better products at lower cost



A new alloy designed for use as a heat transfer medium consists of tin, indium and lead.



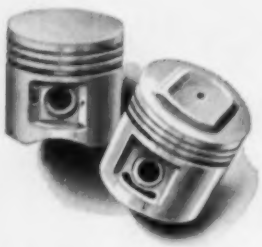
Tin solder coatings on air-conditioning fin coils help prevent odor accumulation.



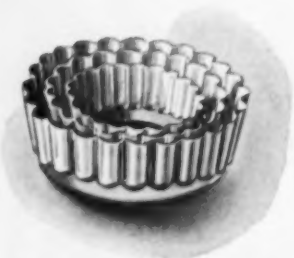
Millions of miles of copper wire are tinned to avert corrosion by rubber insulation.



New heavy-gage tin plate is now being used for automotive air cleaners and oil filters.



Car and airplane pistons of aluminum are often given a coating of tin as a lubricant.



Tin or copper-tin molds are used to give puddings and other desserts a decorative shape.

The number of new ways you can use Straits Tin to make better products at lower cost is today growing faster than ever. And lower cost means higher profit.

To cite just three examples—

New turbo-prop engines in many aircraft have phosphor bronze bushings containing tin. The new chlorinated rubber paints have 5 to 10 times longer life with addition of organotin chemicals. And a new tin-rich tin-zinc-cerium solder for aluminum speeds solder application and has better resistance to salt spray corrosion.

Fortunately there is plenty of tin to meet this increasing list of new uses. Known reserves are adequate for the foreseeable future no matter what the needs of American industry may be.

Over one-third of the world's tin comes from the Federation of Malaya. This country, keystone of Southeast Asia, is steadily winning its war against Communist guerrillas. With increased security in this strategic area you can count on a supply of tin just as dependable as the supplies of other materials produced in the Free World.

Straits Tin from Malaya—at least 99.87% pure—is inert, nontoxic, friction and corrosion resistant. It is highly malleable, has a relatively low melting point (450°F.), and can be alloyed with most other metals.

Whatever you make, a long, careful look at the properties of Straits Tin may show you how to make it better—at lower cost.



A 20-page new booklet gives an informative report on Straits Tin and its many new uses today. Write for a free copy now.

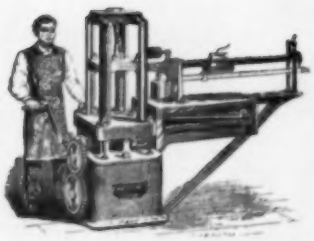
Since February 1953, there have been no restrictions by the U.S. Government on the use of tin.

MALAYAN TIN BUREAU

The Malayan Tin Bureau

Dept. CC-4, 1028 Connecticut Ave., Washington 6, D.C.

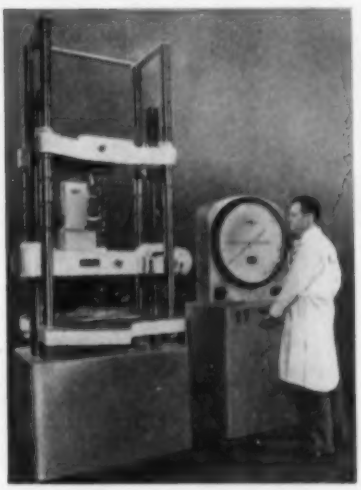
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TINIUS OLSEN TESTING MACHINE CO.

2080 Easton Road · Willow Grove, Pa.

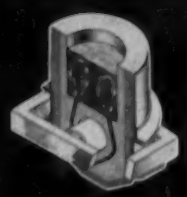
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ONE NAME...FOUR LEADERS

In Melting, Forging and Heat Treating

When it comes to heating metal, one name—and only one—has the standing of AJAX. Four AJAX associates bear this name and each has originated and developed a basically new furnace for the industry. More new industries, perhaps even your own, have developed from AJAX heating than from any other method of heating since the turn of the century. The combined experience and cooperation of all AJAX engineers justifies your confidence that an AJAX recommendation will be the best for your work.



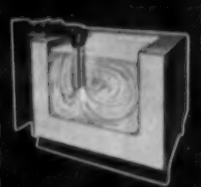
AJAX ELECTRIC FURNACE CORP. . . . 1911

AJAX-Wyatt low frequency induction furnaces for melting or superheating cast and malleable iron, and for melting copper base and zinc alloys in the rolling mill and sand casting foundry. Write 1108 Frankford Avenue, Philadelphia 23, Pa.



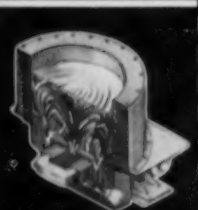
AJAX ELECTROTHERMIC CORP. . . . 1916

AJAX-Northrup high frequency induction melting and heating furnaces using motor generators or spark gap converters for ferrous and non-ferrous metals, including vacuum melting. Also forging, hardening, brazing, carburizing, sintering. Write Trenton 5, New Jersey.



AJAX ELECTRIC COMPANY. 1931

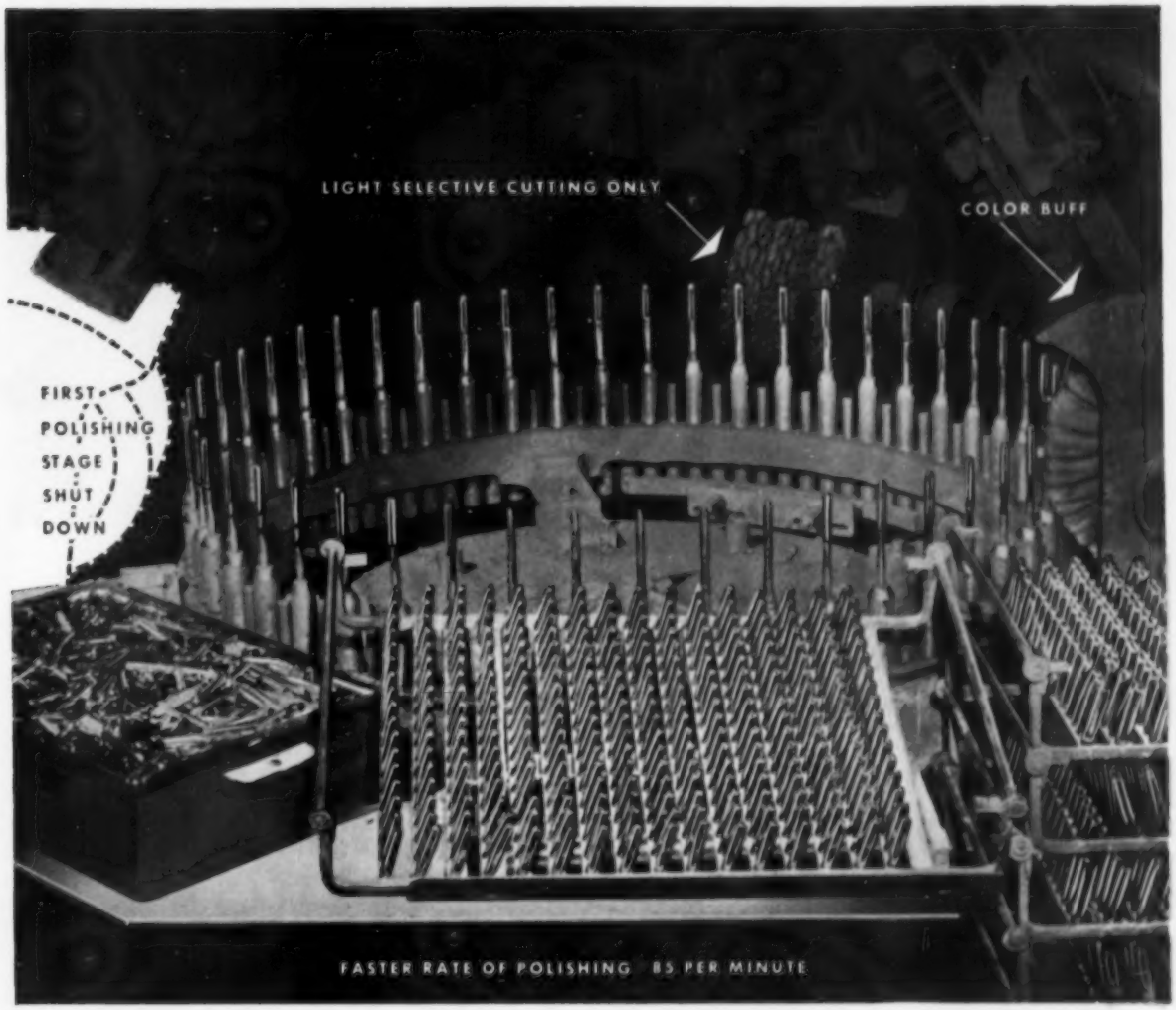
AJAX-Hultgren electric salt bath heat treating furnaces — internally heated — used for aluminizing, annealing, austempering, brazing, carburizing, cleaning, descaling, hardening, martempering, etc. Write 980 Frankford Ave., Phila. 23, Pa.



AJAX ENGINEERING CORP. . . . 1941

AJAX-Tama-Wyatt low frequency induction furnaces for melting, holding, coating, and automatically pouring metals in die-casting, permanent mold, and sand casting foundries — particularly aluminum, zinc, brass, and bronze alloys. Write Trenton 7, New Jersey.

SEE US AT THE METAL SHOW—BOOTH 1619



How Formbrite cuts polishing costs 40% for JARCO



Pens, pencils, and lipstick cases have to be attractive to sell—yet they must be able to take a beating in daily use. The Jarco Metal Products Co., which specializes in drawing metal parts for these and such other products as miniature flashlight cases, and similarly formed products, tried Formbrite,® Anaconda's new drawing brass, shortly after it was announced to the trade.

Superior polishing characteristics combined with excellent drawing properties, plus hardness and scratch resistance, sounded ideal for Jarco products. Formbrite has proved an excellent pressroom material. The uniformity of temper from batch to batch eliminated shutdowns for adjustments in their battery of 12-plunger Waterbury-Farrel presses, which can produce up to 500,000 pieces a day.

It's in the polishing room where Formbrite has really paid off. Jarco uses 50- and 98-spindle continuous-loop machines having two cutting stages and a final color buff stage. The first cutting stage is shut down completely. The second stage is used for only a partial or selective cut in certain areas of the cap—because of the extremely deep draw. The color buff stage does most of the work. The savings in polishing run about 40%, according to David Roberts, vice president.

Formbrite is a premium product at a nonpremium price. Find out for yourself how its superfine grain, excellent drawing properties, strength, and scratch resistance can help you make a better product at lower cost. Write for Publication B-39. Better yet, ask about a sample or a trial batch. Write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

Formbrite

FINE-GRAIN DRAWING BRASS

an ANACONDA® product

made by

The American Brass Company



1001 things now being done by





COLD-ROLL FORMING

As your production requirements grow, new opportunities for effecting economies are offered by cold roll forming components. A few applications are illustrated here: The structural parts of the new Giant 74-ton Boeing Stratofreighter KC-97G are, as in most other planes, made almost entirely from cold-roll-formed shapes because of their high strength-weight ratio.

In the modern warehouse shown at left, the steel decking and rolling steel doors were cold roll formed and installed by the R. C. Mahon Company, Detroit, Michigan.

In the photo of an Armstrong furnace below, the arrows point to the jacket rings and two pilasters framing the front openings—all cold roll formed at a big saving compared with previous methods.

The new Yoder book on Cold Roll Forming is an illustrated story of many of the things which are made lighter, stronger and more accurately by this process than by any other, yet at greatly reduced cost. It is also a complete textbook on the machines, their tooling, operation, and economic possibilities.

A copy is yours for the asking.

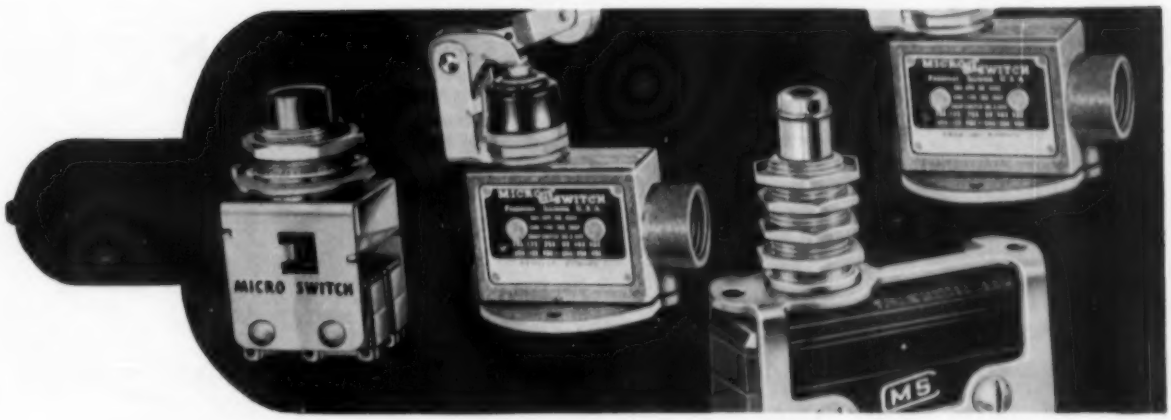
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5595 Walworth Avenue • Cleveland 2, Ohio

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- ★ GANG SLITTING LINES for Coils and Sheets
- ★ PIPE and TUBE MILLS—cold forming and welding

ENGINEERING YODER MANUFACTURING

Armour Ammonia helps make MICRO SWITCH the leader in the precision switch field!



Carbonitriding with Armour ammonia holds the precision parts to watchmaker's tolerances – assures long life, high capacity and accurate repeatability

"In the manufacture of MICRO SWITCH snap-action switches the keynote is precision. Each and every part of the more than 8000 different switches must be held to extremely close tolerances in each step of its production. In our heat treating operations, Armour ammonia is used as the carbonitriding atmosphere and allows the clean, non-decarburizing hardening of switch parts. As a result, each part can be finished to final tolerance *before* heat treating with only a polishing operation necessary afterward.

"In addition, clean, non-decarburizing heat treating with Armour ammonia, done in our own plant, allows much shorter production schedules effecting a saving of both time and money in the fabricating process."

Lloyd Froning, Tool Room Supervisor
Micro Switch Division of
Minneapolis-Honeywell Regulator Co.

Let Armour help solve your metal treating problems

When they specify Armour, manufacturers get more than ammonia. Armour has sponsored a fellowship at a leading technological university for the study of metal treating processes using ammonia. The results of this research are available to you. Furthermore, the men of the Armour Technical Service Department are equipped to handle and answer any problems arising with ammonia installations for metal treating. Write today for free copies of the booklets offered at right. If your problems are unusual or pressing, write, giving full details.



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Please send me free copies of the booklets which I have checked:

- ☐ "Ammonia Cylinder Installations for Metal Treating"
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- ☐ "Investigation into the Carbonitriding of Plain Carbon Steel"
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P10

ARMOUR *Ammonia Division*

Armour and Company • 1355 W. 31st Street
Chicago 9, Ill.

What's New

IN STEEL FROM STOCK

In the news today are many developments of interest to those who specify, buy or work with steel. Ways in which you can raise efficiency and lower costs in your operations may be suggested by the following summary.

Leaded plates—Now lead has been added to E-Z-Cut plate. As a result, E-Z-Cut, which was already considered one of the best free-machining plates on the market, is better than ever. Tests show that New E-Z-Cut cuts even faster, takes a sounder weld and polishes to a better finish than non-leaded E-Z-Cut. And because sulphur content is much lower, New E-Z-Cut is much cleaner steel, free from sulfide stringers. First stocks include thicknesses up through 3".

Biggest stainless steel plates now available from Ryerson stocks. This is the first time that 96" wide plates in thicknesses up to and including 1"—and heavier plates in 80" widths have been carried in stock at plants from coast to coast. Types on hand: 304, 304L, 316 and 316L. Next time, save welding on your big jobs with these bigger plates.

Delivered prices on tubing—Something new in simplified pricing is featured in a booklet just published by Ryerson. For buyers in the 16 metropolitan areas where large Ryerson tubing stocks are located, the booklet gives total delivered prices. There's no figuring to do—no factors to add. For buyers outside these metropolitan areas, a separate book gives prices per 100 feet and transportation charges. And beside every price in all books is a figure that tells you quickly and clearly when you can get a lower price by ordering just a few feet or pounds more. Copies on request.

Give steel-walled buildings a new look with stainless steel siding in mansard pattern, now available for quick shipment from Ryerson. (Galvanized and carbon steel sheets in mansard pattern also available.) The mansard pattern of widely spaced corrugations makes an unusually attractive wall and loss in total sheet area from pattern formation is slight—only about the same as with 2½" corrugated—previously the most economical pattern you could use. Maintenance-free stainless in mansard pattern also has many industrial and miscellaneous-architectural-ornamental applications. New Bulletin 70-5 on request.

New sizes of leaded alloys—Increasing demand for New Rycut 50, fastest machining .50 carbon alloy steel, has prompted Ryerson to increase the range of sizes in stock. Hot rolled rounds, both annealed and heat treated, are now available in large sizes—up through 9½". So heavy shafting, gears, cams, etc. can be produced at savings possible only with Rycut alloys.

Stainless pipe for welding applications—Now there's no need to wait for mill deliveries or to use expensive stabilized types when you want stainless pipe suitable for welding. Type 304L pipe, an extra low carbon type that eliminates the need for stress relieving after welding, has recently been added to Ryerson stocks. Size range: Schedule 40 welded pipe in commonly used sizes from ¼" through 2". Schedule 40 seamless in 3", 4" and 6" pipe sizes.

Supply situation on bars, structurals, plates and sheets—Heavy demand makes it difficult to keep all sizes of these products always on hand. However, we do have thousands of tons of steel ready for quick shipment and, since our stocks are being replenished continually, sizes that are not available today may be on hand tomorrow. So call us next time you need steel.

RYERSON CERTIFIED STEELS

JOSEPH T. RYERSON & SON, INC. PLANTS: NEW YORK • BOSTON • PHILADELPHIA • CLEVELAND
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Metal Progress

Volume 68, No. 4 **October 1955**

As USUAL, the October issue of *Metal Progress* is devoted in large part to the forthcoming National Metal Congress and Exposition, to be held this year in Philadelphia the week of Oct. 17. Headquarters for technical sessions, American Society for Metals, will be at the Benjamin Franklin hotel. (For early birds the Congress really starts the previous Saturday morning with a scientific seminar, lasting through two meetings on Sunday, on "Theory of Alloy Phases".)

The 37th National Metal Exposition will open at Philadelphia's Convention Halls, Monday noon, and be open daily until closing time, 6 p.m., Friday afternoon, Oct. 21. The Convention Halls are near the campus of the University of Pennsylvania, and are easily reached from any hotel by streetcar or bus. Some 23 pages in this issue are devoted to a clasification of exhibitors – what they will exhibit. Merely a glance through this array will convince any metals engineer that here is a showing of important new things which he can really use to advantage in his daily work. A visit – several visits – will richly repay in a harvest of ideas.

Five other national organizations will supplement the A.S.M.'s own technical program with meetings of their own, making this indeed a Metal Congress. These six organizations will hold no less than 67 technical meetings at which 244 papers will be read and discussed, ranging over the whole field of metals, both scientific and practical, to say nothing of several honor lectures and panel discussions. Indeed the scope can only be appreciated by scanning the detailed program on pages 72 to 81. In addition, there is a course of four late-afternoon and evening lectures on causes and cure of embrittlement in metals.

The American Society for Metals and the U. S. Atomic Energy Commission are cooperating for the third time in presenting new information gained in the extensive work in the national laboratories and in the various operations. This time there are two sessions on "Powder Metallurgy in Atomic Energy". Also the Office of Ordnance Research, U. S. Army, is bringing experts from England and Australia to join Americans in a lengthy conference on ductile chromium metal and its high alloys. A conference on vacuum-melted metals will be held late Monday afternoon and evening.

Another feature will be two ⊕ sessions in cooperation with the Industrial Heating Equipment Assoc. on heating methods and mechanized heat treating equipment, matters which will be fully reported in the November issue of *Metal Progress*. The difficulty a visitor will have is in selecting what simply cannot be missed on this ample bill of fare.

The ⊕ Annual Meeting will convene earlier than usual (9:00 a.m. on Wednesday morning, Oct. 19) and numerous awards will be made in this session rather than at the Annual Banquet, where the spotlight will be on the principal speaker, Lewis L. Strauss, chairman of the U.S. Atomic Energy Commission.

Come to Philadelphia for the Metal Show!

• CONSOLIDATED PROGRAM •

37th National Metal Congress

and National Metal Exposition

AMERICAN SOCIETY FOR METALS

INSTITUTE OF METALS DIVISION,
AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS (A.I.M.E.)

AMERICAN WELDING SOCIETY (A.W.S.)

SOCIETY FOR NONDESTRUCTIVE TESTING (S.N.T.)

METALS DIVISION, SPECIAL LIBRARIES ASSOCIATION (S.L.A.)

INDUSTRIAL HEATING EQUIPMENT ASSOCIATION (I.H.E.A.)

Saturday, Oct. 15, 1955

9:30 A.M., 2:00 P.M., 8:00 P.M. Seminar on Theory of Alloy Phases, Benjamin Franklin Hotel

Sunday, Oct. 16

9:30 A.M. Seminar on Theory of Alloy Phases, Benjamin Franklin

2:00 P.M. Seminar on Theory of Alloy Phases, Benjamin Franklin

Monday, Oct. 17

9:00 A.M. A.I.M.E. Research in Progress, Adelphia

9:00 A.M. A.I.M.E. Deformation, Adelphia

9:00 A.M. S.N.T. Educational Survey, Sylvania

9:30 A.M. Titanium, Benjamin Franklin

9:30 A.M. Mechanical Properties, Benjamin Franklin

10:00 A.M. A.W.S. Prize Awards, Bellevue-Stratford

10:30 A.M. A.W.S. Adams Lecture, Bellevue-Stratford

10:30 A.M. U.S. Army Conference on Ductile Chromium Metal, Benjamin Franklin

12:00 M. National Metal Exposition opens, Convention Hall

1:30 P.M. S.N.T. Educational Survey, Sylvania

2:00 P.M. Titanium and Zirconium, Benjamin Franklin

2:00 P.M. U.S. Army Conference on Ductile Chromium Metal, Benjamin Franklin

2:00 P.M. A.W.S. Co_2 - Gas-Shielded Welding, Bellevue-Stratford

2:00 P.M. A.W.S. Resistance Welding, Bellevue-Stratford

2:00 P.M. A.W.S. Weldability and Research, Bellevue-Stratford

2:00 P.M. A.I.M.E. Seminar on Recrystallization and Grain Growth, Adelphia

2:00 P.M. A.I.M.E. Symposium on Nuclear Metallurgy, Adelphia

4:30 P.M. Conference on Vacuum Melted Metals, Benjamin Franklin

8:00 P.M. Conference on Vacuum Melted Metals, Benjamin Franklin

8:00 P.M. A.I.M.E. Symposium on Nuclear Metallurgy, Adelphia

10:30 P.M. National Metal Exposition closes

Tuesday, Oct. 18

9:00 A.M. U.S. Army Conference on Ductile Chromium Metal, Benjamin Franklin

9:00 A.M. A.I.M.E. Deformation, Adelphia

9:00 A.M. A.I.M.E. Symposium on Titanium, Adelphia

9:00 A.M. S.N.T. Production Testing, Sylvania

9:30 A.M. Tempering of Steel, Benjamin Franklin

9:30 A.M. Deformation, Benjamin Franklin

9:30 A.M. A.W.S. Weldability and Research, Bellevue-Stratford

9:30 A.M. A.W.S. Structures, Bellevue-Stratford

9:30 A.M. A.W.S. Inspection and Testing, Bellevue-Stratford

11:30 A.M. Canadian Fellowship Hour and Luncheon, Benjamin Franklin

12:00 M. National Metal Exposition opens, Convention Hall

12:00 M. Battelle Alumni Luncheon, Benjamin Franklin
12:00 M. Armour Research Luncheon, Benjamin Franklin
2:00 P.M. ⊜ Steel, Benjamin Franklin
2:00 P.M. ⊜ U.S. Army Conference on Ductile Chromium Metal, Benjamin Franklin
2:00 P.M. ⊜ I.H.E.A. Furnaces, Combustion Equipment and Induction Heating, Convention Hall
2:00 P.M. A.W.S. Weldability and Research, Bellevue-Stratford
2:00 P.M. A.W.S. Shipbuilding, Bellevue-Stratford
2:00 P.M. A.W.S. Welding Equipment, Bellevue-Stratford
2:00 P.M. A.I.M.E. Symposium on Titanium, Adelphia
2:00 P.M. A.I.M.E. Diffusion and Related Phenomena, Adelphia
2:00 P.M. S.N.T. Aircraft Inspection, Sylvania
4:30 P.M. ⊜ Lecture Course on Embrittlement Phenomena, Convention Hall
4:30 P.M. A.W.S. Educational Lecture on Mechanical Properties of Steel Weld Metal, Bellevue-Stratford
8:00 P.M. ⊜ Lecture Course on Embrittlement Phenomena, Convention Hall
10:30 P.M. National Metal Exposition closes

Wednesday, Oct. 19

7:00 A.M. S.L.A. Field Trip to Bethlehem Steel Co.
7:30 A.M. ⊜ Chapter Chairmen's Breakfast, Benjamin Franklin
8:30 A.M. Industrial Gas Breakfast, Penn Sherwood
9:00 A.M. ⊜ Annual Meeting, Benjamin Franklin
9:00 A.M. A.I.M.E. Constitution and General Metallurgy, Adelphia
9:00 A.M. A.I.M.E.-A.S.M.E. Joint Symposium on High-Temperature Alloys, Adelphia
9:00 A.M. S.N.T. Marine Inspection, Sylvania
9:30 A.M. A.W.S. Stainless, Bellevue-Stratford
9:30 A.M. A.W.S. Electrodes, Bellevue-Stratford
9:30 A.M. A.W.S. Applications, Bellevue-Stratford
10:00 A.M. ⊜ Campbell Memorial Lecture, Benjamin Franklin
12:00 M. National Metal Exposition opens, Convention Hall
12:00 M. Alumni Luncheons, Benjamin Franklin
2:00 P.M. ⊜ Steel, Benjamin Franklin
2:00 P.M. ⊜ Molybdenum, Vanadium and Tantalum, Benjamin Franklin
2:00 P.M. ⊜ I.H.E.A. Mechanized Heat Treating Equipment, Convention Hall
2:00 P.M. A.I.M.E.-A.S.M.E. Joint Symposium on High-Temperature Alloys, Adelphia
2:00 P.M. A.I.M.E. Phase Transformations, Adelphia
2:00 P.M. A.W.S. Titanium and Molybdenum, Bellevue-Stratford
2:00 P.M. A.W.S. Electrodes, Bellevue-Stratford
2:00 P.M. A.W.S. Pressure Vessels, Bellevue-Stratford
2:00 P.M. S.N.T. Annual Meeting and Lester Honor Lecture, Sylvania
4:30 P.M. ⊜ Lecture Course on Embrittlement Phenomena, Convention Hall
4:30 P.M. A.W.S. Educational Lecture on Mechanical Properties of Steel Weld Metal, Bellevue-Stratford
8:00 P.M. ⊜ Lecture Course on Embrittlement Phenomena, Convention Hall
10:30 P.M. National Metal Exposition closes

Thursday, Oct. 20

9:00 A.M. S.N.T. Ordnance Inspection, Sylvania
9:30 A.M. ⊜ Stainless Steels, Benjamin Franklin
9:30 A.M. ⊜ A.E.C. Powder Metallurgy in Atomic Energy, Benjamin Franklin
9:30 A.M. A.W.S. Aluminum, Bellevue-Stratford
9:30 A.M. A.W.S. Piping and Pressure Vessels, Bellevue-Stratford
9:30 A.M. A.W.S. Applications, Bellevue-Stratford
9:30 A.M. S.L.A. Indexing Systems in Industrial Libraries, Sylvania
10:00 A.M. National Metal Exposition opens, Convention Hall
2:00 P.M. ⊜ Stainless Steels, Benjamin Franklin
2:00 P.M. ⊜ A.E.C. Powder Metallurgy in Atomic Energy, Benjamin Franklin
2:00 P.M. S.L.A. Powder Metallurgy, Sylvania
2:00 P.M. S.N.T. Casting, Forging and Weld Inspection, Sylvania
6:00 P.M. National Metal Exposition closes
6:30 P.M. ⊜ Cocktail Hour, Benjamin Franklin
7:30 P.M. ⊜ Annual Banquet, Benjamin Franklin
10:30 P.M. ⊜ Dancing, Benjamin Franklin

Friday, Oct. 21

9:00 A.M. S.L.A. Field Trip to American Society for Testing Materials
9:30 A.M. A.W.S. Brazing, Bellevue-Stratford
9:30 A.M. A.W.S. Maintenance and Cutting, Bellevue-Stratford
9:30 A.M. A.W.S. Applications, Bellevue-Stratford
10:00 A.M. National Metal Exposition opens, Convention Hall
12:00 M. ⊜ Distinguished Service Luncheon for 25-Year Members and Students
2:00 P.M. S.L.A. Field Trip to Franklin Institute
6:00 P.M. National Metal Congress and National Metal Exposition end.

Technical Program

Seminar on Theory of Alloy Phases

All Meetings in Benjamin Franklin Hotel, Philadelphia

Coordinator: *Paul A. Beck*, University of Illinois

Saturday, Oct. 15

9:30 A.M. — First Session

Bonding Forces in Solids
by *Fred Seitz*, University of Illinois

Band Theory of Bonding in Metals
by *J. C. Slater*, Massachusetts Institute of Technology

Density of States as Determined by Soft X-Ray Spectroscopy
by *C. H. Shaw*, Ohio State University

2:00 P.M. — Second Session

Intermediate Phases and Electronic Structure
by *T. Massalski*, University of Chicago

Crystal Structure and Atomic Size
by *F. Laves*, Polytechnic Technical Institute, Zurich, Switzerland

Bonding Forces in Alkali Metals
by *H. Brooks*, Cruft Laboratory, Harvard University

8:00 P.M. — Third Session

The Electronic Structure of Metals and Alloys
by *L. Pauling*, California Institute of Technology

Sunday, Oct. 16

9:30 A.M. — Fourth Session

Intermediate Phases in Alloys of the Transition Elements
by *Pol Duwez*, California Institute of Technology

Ferromagnetism, Antiferromagnetism and Crystal Structure
by *Clarence Zener*, University of Chicago

Atomic and Magnetic Ordering in Intermediate Phases
by *J. S. Kasper*, General Electric Co.

2:00 P.M. — Fifth Session

Atomic Moments of Transition Elements in Solid Solution Alloys
by *C. Shull*, Massachusetts Institute of Technology (formerly Oak Ridge National Laboratory)

Solid Solutions and Ordering
by *B. Averbach*, Massachusetts Institute of Technology

Alloy Phase Diagrams
by *G. V. Raynor*, Birmingham University, England

Daily Technical Sessions

All Meetings in Benjamin Franklin Hotel, Philadelphia

Monday, Oct. 17

9:30 A.M. — Titanium

The Rate of Diffusion of Carbon in Alpha and Beta Titanium
by *F. C. Wagner*, *E. J. Bucur* and *M. S. Steinberg*, Horizons, Inc.

Hydrogen Contamination in Descaling and Acid Pickling of Titanium
by *G. A. Lenning*, *C. M. Craighead* and *R. I. Jaffee*, Battelle Memorial Institute

Mechanical Properties of Ti-Cr-Mo Alloys as Affected by Grain Size and Grain Shape
by *H. R. Ogden*, *F. C. Holden* and *R. I. Jaffee*, Battelle Memorial Institute

Investigation of the Heat Treatability of the 6% Aluminum, 4% Vanadium Titanium-Base Alloy
by *R. G. Sherman* and *H. D. Kessler*, Titanium Metals Corp. of America

9:30 A.M. — Mechanical Properties

Notch-Ductile High-Strength Nodular Irons
by *G. A. Sandoz*, *H. F. Bishop* and *W. S. Pellini*, Naval Research Laboratory

Fatigue and Anisotropy in Copper
by *M. L. Ebner* and *W. A. Backofen*, Metals Processing Laboratory, Massachusetts Institute of Technology

The Influence of Vibration on the Solidification of an Aluminum Alloy
by *R. S. Richards*, Titanium Metals Corp. and *W. Rostoker*, Armour Research Foundation

2:00 P.M. — Titanium and Zirconium

Nature and Decomposition Kinetics of Alpha Prime in Titanium-Vanadium Alloys
by *F. R. Brotzen*, Rice Institute and *E. L. Harmon* and *A. R. Troiano*, Case Institute of Technology

Metallography of Tempering of Alpha-Prime in Titanium Alloys
by *R. F. Domagala* and *W. Rostoker*, Armour Research Foundation

Tensile Properties of Zirconium-Chromium Alloys — Particle-Strengthening Effects
by *J. H. Keeler*, General Electric Co.

Progress in the Development of Creep Resistant Zirconium Alloys
by *Walston Chubb*, Battelle Memorial Institute

Monday, Oct. 17

4:30 P.M. and 8:00 P.M. — Conference on Vacuum Melted Metals

Tuesday, Oct. 18

9:30 A.M. — Tempering of Steel

Some Effects of Silicon on the Mechanical Properties of High Strength Steels
by *C. H. Shih*, *B. L. Averbach* and *Morris Cohen*, Massachusetts Institute of Technology

Some Relationships Between Endurance Limit and Torsional Properties of Steel
by *S. T. Ross*, *R. P. Sernka* and *W. E. Jominy*, Chrysler Corp.

The Influence of Molybdenum and Tungsten on Temper Embrittlement
by *A. E. Powers*, General Electric Co.

Hardness of Tempered Martensite in Carbon and Low-Alloy Steels
by *R. A. Grange* and *R. W. Baughman*, United States Steel Corp.

9:30 A.M. — Deformation

Deformation of Beryllium Single Crystals at 25 to 500° C.
by *H. T. Lee* and *R. M. Brick*, University of Pennsylvania

Grain-Boundary Creep in Aluminum Bicrystals
by *F. N. Rhines*, *W. E. Bond* and *M. A. Kissel*, Carnegie Institute of Technology

Deformation and Fracture Mechanisms of Polycrystalline Magnesium at Low Temperatures
by *F. E. Hauser*, *P. R. Landon* and *J. E. Dorn*, University of California

Influence of Cold Work on Strength of Steel at Elevated Temperatures
by *Paul Shahinian*, Naval Research Laboratory

2:00 P.M. — Steel

Inhibition by Nitrogen of Graphitization in Steel
by *G. V. Smith*, Cornell University and *B. W. Royle*, American Steel and Wire Div., U.S. Steel Corp.

An Approach to the Study of the Effect of Rare Earth Additions to Steel by Use of Radioactive Tracer Techniques
by *C. S. DuMont* and *J. E. Gates*, Battelle Memorial Institute and *C. N. Henderson*, Mallinckrodt Chemical Works

The Optimum Boron Content for Hardenability
by *J. C. Shyne*, *E. R. Morgan* and *D. N. Frey*, Ford Motor Co.

On Banding in Steel
by *C. Jatczak*, *D. J. Girardi* and *E. S. Rowland*, Timken Roller Bearing Co.

Wednesday, Oct. 19

9:00 A.M. — Annual Meeting

Edward deMille Campbell Memorial Lecture
by *Robert H. Aborn*, United States Steel Corp.

2:00 P.M. — Steel

Some Effects of Metal Removal and Heat Treatment on the Surfaces of Hardened Steel
by *Karl E. Beu*, Goodyear Atomic Corp. and *D. P. Koistinen*, General Motors Corp.

Effect of Temperature on Delayed Yielding of Mild Steel for Short Loading Duration
by *Jos. M. Krafft*, Naval Research Laboratory

Effect of Tempering Temperature on Stress-Corrosion Cracking and Hydrogen Embrittlement of Martensitic Stainless Steels
by *P. Lillys* and *A. E. Nehrenberg*, Crucible Steel Co. of America

Static Fatigue of High-Strength Steel
by *R. H. Raring* and *J. A. Rinebolt*, Naval Research Laboratory

2:00 P.M. — Molybdenum, Vanadium, Tantalum

The Initiation of Discontinuous Yielding in Ductile Molybdenum
by *J. A. Hendrickson*, *D. S. Wood* and *D. S. Clark*, California Institute of Technology

Properties of Vanadium Consolidated by Extrusion
by *C. E. Lacy* and *C. J. Beck*, General Electric Co., Knolls Atomic Power Laboratory

The Mechanical Properties of Vanadium-Base Alloys
by *W. Rostoker* and *A. S. Yamamoto*, Armour Research Foundation and *R. E. Riley*, Rem-Cru Titanium Corp.

Rolling Textures in Tantalum in Relation to BCC Metals
by *J. W. Pugh* and *W. R. Hibbard, Jr.*, General Electric Co.

Thursday, Oct. 20

9:30 A.M. — Stainless Steels

Influence of Alloying Elements on the Impact Transition Behavior of 12% Cr Steels Aged at 900° F.
by *E. J. Whittenberger* and *E. R. Rosenow*, United States Steel Corp.

Creep-Rupture Properties of Cold Worked Type 347 Stainless Steel
by *N. J. Grant*, *A. G. Bucklin* and *Warren Rowland*, Massachusetts Institute of Technology

Notch Ductility of Type 410 (12% Cr) Stainless Steel
by *F. A. Brandt*, *H. F. Bishop* and *W. S. Pellini*, Naval Research Laboratory

The Influence of Strain Rate and Temperature on the Ductility of Austenitic Stainless Steel
by *G. W. Form* and *W. M. Baldwin, Jr.*, Case Institute of Technology

Convention Program, Continued

Thursday, Oct. 20

2:00 P.M. — Stainless Steels

High-Nitrogen Austenitic Cr-Mn Steels
by *V. F. Zackay*, Ford Motor Co.
J. L. Carlson, Hoskins Mfg. Co.
and *P. L. Jackson*, Misco Precision Casting Co.

The Effect of Composition and Structure on the Creep-Rupture Properties of 18-8 Stainless Steels
by *F. C. Monkman*, *P. E. Price* and *N. J. Grant*, Massachusetts Institute of Technology

Austenitic Fe-Cr-C-N Stainless Steels
by *G. F. Tisinai*, *J. K. Stanley* and *C. H. Samans*, Standard Oil Co. of Indiana

Effects of Chemical Composition and Heat Treatment Upon the Microstructure and Corrosion Resistance of A.I.S.I. Types 309 and 310
by *D. J. Carney* and *E. R. Rosenow*, U.S. Steel Corp.

7:30 P.M. — Annual Banquet

Speaker: *Lewis L. Strauss*, Chairman, U.S. Atomic Energy Committee

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Lecture Course on Embrittlement Phenomena

Meetings at Convention Hall, Philadelphia

Lecturer: *B. R. Queneau*, Chief Metallurgist, U. S. Steel Corp., Duquesne, Pa.

Tuesday, Oct. 18

4:30 P.M. — Summary of Embrittlement Phenomena and General Discussion of their Effects

8:00 P.M. — Work Hardening and Precipitation Embrittlement

Wednesday, Oct. 19

4:30 P.M. — Embrittlement by Gases

8:00 P.M. — Temper Brittleness and Sigma Phase

Powder Metallurgy in Atomic Energy

Jointly Sponsored by U. S. Atomic Energy Commission and American Society for Metals

Meetings at Benjamin Franklin Hotel, Philadelphia

General Chairman: *Henry H. Hausner*
Manager of Atomic Energy Engineering, Sylvania Electric Products, Inc.

Thursday, Oct. 20

9:30 A.M. — First Session

General Metallurgical Problems in the Design of Nuclear Power Reactors
by *Vincent P. Calkins*, Aircraft Nuclear Propulsion Project, General Electric Co.

Preparation of Metal Powders for Nuclear Reactor Purposes
by *Premo Chiotti* and *Harley A. Wilhelm*, Institute for Atomic Research, Iowa State College

The Latest Developments in the Theory of Sintering
by *A. Pranatis* and *Leslie L. Seigle*, Sylvania Elecric Products, Inc.

The Powder Metallurgy of Beryllium and Zirconium
by *Harold Hirsch*, Knolls Atomic Power Laboratory, General Electric Co.

2:00 P.M. — Second Session

Alloy Formation by Powder Metallurgy
by *Henry A. Saller* and *Frank A. Rough*, Battelle Memorial Institute

New Methods of Powder Metallurgy for Nuclear Reactor Purposes
by *John H. Cooks* and *W. D. Manly*, Oak Ridge National Laboratory

Safe Handling of Pyrophoric and Radioactive Materials
by *L. R. Kelman*, *A. B. Shuck* and *R. C. Goertz*, Argonne National Laboratory

Summary of Recently Disclosed Information on Thorium, Uranium and Special Metals for Nuclear Reactors
by *Henry H. Hausner*, Sylvania Electric Products, Inc.

Conference on Ductile Chromium Metal and Its High Alloys

Jointly Sponsored by Office of Ordnance Research, U.S. Army, and American Society for Metals

All Meetings at Benjamin Franklin Hotel, Philadelphia

Monday, Oct. 17

10:30 A.M. — World-Wide Research on Ductile Chromium

Introductory Remarks
by *Col. P. N. Gillon*, Ordnance Dept., U.S. Army

Research on Chromium in America
by *W. J. Kroll*, Consulting Metallurgist

Research on Chromium in Australia
by *Henry L. Wain*, Department of Supply, Government of Australia

Research on Chromium in Europe
by *A. H. Sully*, Fulmer Research Institute, England

2:00 P.M. — Physical Metallurgy of High-Chromium Alloys

Influence of Chromium Metal Purity on the Properties of Chromium Alloys
by *Robert I. Jaffee*, Battelle Memorial Institute

The Solubility of Nitrogen and Oxygen in Solid Chromium
by *A. A. Burr*, Rensselaer Polytechnic Institute

The Ternary System of Chromium-Nickel Alloys Containing up to 5% Nitrogen
by *N. J. Grant*, Massachusetts Institute of Technology

Oxidation of Chromium and Chromium Alloys
by *W. Martin Fassel, Jr.*, University of Utah

The Kinetics of the Formation of the Sigma Phase in Chromium-Iron Alloys
by *Pol Duwez* and *Howard Martens*, California Institute of Technology

Tuesday, Oct. 18

9:00 A.M. — Chromium Metal

Preparation and Properties of Iodide Chromium
by *I. E. Campbell*, Battelle Memorial Institute

Electro-Winning of Chromium From Trivalent Solutions
by *M. C. Carosella* and *J. D. Mettler*, Electro Metallurgical Co.

Melting Point of High-Purity Chromium
by *LeRoy L. Wyman*, National Bureau of Standards

Mechanical Properties of Massive Chromium
by *G. Asai* and *K. D. Deardorf*, U.S. Bureau of Mines

Effects of Impurities on the Ductility of Chromium
by *W. H. Smith* and *A. U. Seybolt*, General Electric Co.

Volume Change and Evolution of Gases on Heating Electrolytic Chromium
by *Kenneth A. Moon* and *George A. Consolazio*, Watertown Arsenal

2:00 P.M. — High-Chromium Alloys

Ductile Chromium-Iron Alloys
by *R. W. Fountain* and *J. L. Lamont*

Toughness and Mechanical Properties of Chromium-Iron Alloys
by *H. Kato* and *E. T. Hayes*, U.S. Bureau of Mines

Creep-Rupture Properties of Chromium-Nickel Alloys
by *N. J. Grant*, Massachusetts Institute of Technology

A Forgeable Chromium-Iron Based Alloy
by *D. P. Moon, H. A. Blank* and *A. M. Hall*, Watertown Arsenal

Metallography of Chromium and Chromium-Rich Alloys
by *W. D. Forgeng* and *G. T. Motock*, Union Carbide & Carbon Research Laboratories

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Industrial Heating Sessions

Jointly sponsored by Industrial Heating Equipment Association and American Society for Metals

Meetings at Convention Hall, Philadelphia

Chairman: *Alfred E. Tarr*, Leeds and Northrup Co.

Tuesday, Oct. 18

2:00 P.M. — Furnaces, Combustion Equipment and Induction Heating

Vacuum Melting by Induction and Arc
by *Frank Chesnut*, Ajax Electrothermic Corp.

Batch-Type Strip Annealing Furnaces—Multiple and Single Stack
by *Fred Olmstead*, Lee Wilson Engineering Co.

Combustion Systems in Steel Mills
by *Fred Bloom*, Bloom Engineering Co.

Wednesday, Oct. 19

2:00 P.M. — Mechanized Heat Treating Equipment

Molten Baths and Mechanisms
by *Leon Rosseau*, Ajax Electric Co.

Mechanized Batch-Type Furnaces
by *Martin Neumeyer*, Sunbeam Corp.

Mechanized Continuous-Type Furnaces
by *George McCormick*, Industrial Heating Equipment Co.

Metallurgical Aspects Associated With Induction Heating
by *Harry Osborn*, Tocco Div., Ohio Crankshaft Co.

Institute of Metals Division

American Institute of Mining and Metallurgical Engineers

All Sessions at Adelphia Hotel, Philadelphia

Monday, Oct. 17

9:00 A.M. — Research in Progress

9:00 A.M. — Seminar on Deformation

Internal Friction in Zirconium
by *W. J. Bratina*, Ontario Research Foundation and *W. C. Winegard*, University of Toronto

Creep of Polycrystalline Tin
by *J. E. Breen* and *J. Weertman*, Naval Research Laboratory

Interaction of Precipitation, Solid Solution Content and Creep in Magnesium-Aluminum Alloys
by *C. S. Roberts*, Dow Chemical Co.

Tensile Deformation of Germanium Single Crystals
by *R. P. Carreker, Jr.*, General Electric Co.

Tensile Deformation of Molybdenum as a Function of Temperature and Strain Rate
by *R. P. Carreker, Jr.*, and *R. W. Guard*, General Electric Co.

Mechanism of Plastic Flow in Titanium at Low and High Temperatures
by *F. D. Rosi*, RCA Laboratories

F. C. Perkins and *L. L. Seigle*, Sylvania Electric Products, Inc.

Strain Rate Effects in Tungsten
by *J. H. Bechtold*, Westinghouse Electric Corp.

Effects of Oxygen, Nitrogen and Carbon on the Ductility of Cast Molybdenum
by *L. E. Olds* and *G. W. P. Rengstorff*, Battelle Memorial Institute

Strain-Induced Porosity and Hydrogen Embrittlement in Zirconium
by *F. Forscher*, Westinghouse Electric Corp.

2:00 P.M. — Seminar on Recrystallization and Grain Growth

Recrystallization Textures of a Cold Rolled Aluminum Single Crystal
by *Y. C. Liu*, New York University and *W. R. Hibbard, Jr.*, General Electric Co.

Primary Recrystallization Textures in Cold Rolled Silicon-Iron Crystals
by *C. G. Dunn*, General Electric Co. and *P. K. Koh*, Allegheny Ludlum Steel Corp.

Preferred Orientations in Rolled and Annealed Titanium
by *J. H. Keeler* and *A. H. Geisler*, General Electric Co.

Measurement of Grain Growth Rates in Recrystallization
by *C. D. Graham, Jr.*, General Electric Co. and *R. W. Cahn*, University of Birmingham, England

Grain Growth Rates and Orientation Relationships in the Recrystallization of Aluminum Single Crystals
by *C. D. Graham, Jr.*, General Electric Co. and *R. W. Cahn*, University of Birmingham, England

2:00 P.M. — Symposium on Nuclear Metallurgy

Plutonium Metal
by *E. R. Jette*, Los Alamos Scientific Laboratory

Physical Metallurgy of Thorium
by *H. A. Wilhelm* and *B. A. Rogers*, Iowa State College

Physical Metallurgy of Uranium
by *F. G. Foote*, Argonne National Laboratory

8:00 P.M. — Symposium on Nuclear Metallurgy*

Power Reactors
by *A. M. Weinberg*, Oak Ridge National Laboratory

Problems in Materials for Atomic Power
by *J. B. Howe*, North American Aviation, Inc.

Tuesday, Oct. 18

9:00 A.M. — Seminar on Deformation

Effects of Alloying Elements on Plastic Deformation in Aluminum Single Crystals
by *E. E. Underwood* and *L. L. Marsh*, Battelle Memorial Institute

Tensile Creep of High-Purity Aluminum
by *R. W. Guard* and *W. R. Hibbard, Jr.*, General Electric Co.

Creep of Copper at Intermediate Temperatures
by *T. E. Tietz* and *J. E. Dorn*, University of California

Creep-Rupture by Vacancy Condensation
by *E. S. Machlin*, Columbia University

Cleavage Steps on Zinc Monocrystals —Their Origins and Patterns
by *J. J. Gilman*, General Electric Co.

On the Collapse of Dislocation Loops During Annealing
by *Jack Washburn*, University of California

9:00 A.M. — Symposium on Titanium

Keynote Address
by *Herbert H. Kellogg*, Chairman of Titanium Advisory Committee, Office of Defense Mobilization

Present Status of Titanium Development
by *D. J. McPherson*, Armour Research Foundation

Panelists:
S. A. Herres, Titanium Metals Corp.
L. S. Busch, Mallory-Sharon Titanium Corp.
V. W. Whitmer, Republic Steel Corp.
D. W. Kaufmann, Rem-Cru Titanium Corp.
Harold Margolin, New York University

*Includes a social hour at which beer and soft drinks will be provided at a charge of $1.00 per person to cover costs.

Tuesday, Oct. 18

9:00 A.M. — Symposium on Titanium (Cont.)

Status of Titanium Fabrication and Use (a Report of the Department of Defense, Titanium Steering Committee)
by *J. H. Garrett*, Office of Assistant Secretary of Defense

Panelists:
Lt. Col. L. W. Herway, United States Air Force
J. J. Harwood, Office of Naval Research
N. L. Reed, Watertown Arsenal
C. B. Voldrich, Battelle Memorial Institute

2:00 P.M. — Symposium on Titanium

The Background for Practical Heat Treatment of Various Titanium Alloy Types
by *P. D. Frost*, Battelle Memorial Institute

Panelists:
W. L. Finlay, Rem-Cru Titanium Corp.
B. Morelander, North American Aviation
S. Abkowitz, Watertown Arsenal
William Rostoker, Armour Research Foundation
H. J. Middendorp, Materials Laboratories, Wright-Patterson Air Force Base

Future Use Pattern for Titanium
by *Col. B. S. Mesick*, Retired, Arthur D. Little, Inc.

Panelists:
L. Schapiro, Douglas Aircraft Corp.
C. W. Alesh, Consolidated Vultee Aircraft Corp.
R. Thielemann, Pratt and Whitney Aircraft Corp.
V. Kudryk, Chemical Construction Co.

2:00 P.M. — Diffusion and Related Phenomena

Diffusion of Nitrogen in Iron
by *P. E. Busby* and *Cyril Wells*, Carnegie Institute of Technology and *D. P. Hart*, Pittsburgh Plate Glass Co.

Diffusion in Liquid Lead
by *S. J. Rothman*, Argonne National Laboratory and *L. D. Hall*, Stanford Research Institute

Self-Diffusion in Solid Nickel
by *R. E. Hoffman*, *F. W. Pikus*, and *R. A. Ward*, General Electric Co.

Diffusion and Marker Movements in Beta Brass
by *U. S. Landergren*, SKF Industries, Inc.
C. E. Birchenall, Princeton University
and *R. F. Mehl*, Carnegie Institute of Technology

Self-Diffusion in Single and Polycrystals of Zinc at Low Temperatures
by *F. E. Jaumot, Jr.*, and *R. L. Smith*, Franklin Institute

Some Studies of Al-Cu and Al-Zr Solid State Bonding
by *Samuel Storcheim*, Sylvania Electric Products, Inc.

On the Rate of Sintering
by *Gerhard Bockstiegel*, Sintermetallwerk Krebsoge Smett, Germany

Temperature Gradient Zone Melting
by *W. G. Pfann*, Bell Telephone Laboratories, Inc.

Thermodynamic Properties of Solid Iron-Gold Alloys
by *L. L. Seigle*, Sylvania Electric Products, Inc.

A Search for Oxidation-Resistant Alloys of Molybdenum
by *G. W. P. Rengstorff*, Battelle Memorial Institute

Wednesday, Oct. 19

9:00 A.M. — Constitution and General Metallurgy

Titanium-Rich Corner of the Ti-Al-V System
by *I. I. Rausch* and *F. A. Crossley*, Armour Research Foundation and *H. D. Kessler*, Titanium Metals Corp. of America

Titanium-Molybdenum-Oxygen System
by *P. A. Farrar*, *L. P. Stone*, and *Harold Margolin*, New York University

Thorium-Columbium and Thorium-Titanium Alloy Systems
by *O. N. Carlson*, *J. M. Dickerson*, *H. E. Lunt*, and *H. A. Wilhelm*, Iowa State College

System Zirconium-Nitrogen
by *R. F. Domagala*, *D. J. McPherson*, and *M. Hansen*, Armour Research Foundation

Fabrication of Powdered Thorium
by *W. W. Beaver*, *K. G. Wikle*, and *J. G. Klein*, Brush Beryllium Co.

Metallographic Identification of Monmetallic Inclusions in Uranium
by *R. F. Dickerson*, *A. F. Gerds*, and *D. A. Vaughan*, Battelle Memorial Institute

9:00 A.M. — Joint Symposium on High-Temperature Alloys

(With Metals Engineering Division of A.S.M.E.)

Materials for Use up to 1250° F.

Alloy Design of Material up to 1250° F.
by *A. I. Rush*, University of Michigan

Stability of Alloy Steels
by *A. B. Wilder*, *E. F. Ketterer*, and *D. B. Collyer*, National Tube Div., U.S. Steel Corp.

Some Practical Aspects of High-Temperature Design Below 1250° F.
by *E. C. Chapman*, Combustion Engineering, Inc.

2:00 P.M. — Joint Symposium on High-Temperature Alloys

Materials for Use Above 1250° F.

Principles of Design and Development of Alloys for Use Above 1250° F.
by *N. J. Grant*, Massachusetts Institute of Technology

Over 6,000,000 Flying Hours Later
by *A. W. F. Green*, General Motors Corp.

2:00 P.M. — Phase Transformations

High-Speed Quenching Dilatometer
by *F. E. Martin* and *R. H. Raring*, Naval Research Laboratory

Heat Treatment and Mechanical Properties of Titanium-Iron Alloys
by *F. C. Holden*, *H. R. Ogden*, and *R. I. Jaffee*, Battelle Memorial Institute

A.I.M.E. Institute of Metals Division

(Wednesday Afternoon, Phase Transformations, Continued)

Effect of Carbon on Some Properties of Ti-Mo Alloys
by *D. W. Levinson*, *W. Rostoker*, and *A. Yamamoto*, Armour Research Foundation

Hardenability of Titanium Alloys Calculated From Composition — A Preliminary Examination
by *L. D. Jaffe*, California Institute of Technology

Preliminary Examination of the Quenching of Titanium Alloys
by *L. D. Jaffe*, California Institute of Technology

Sigma Nucleation Times in Stainless Steels
by *G. F. Tisinai*, *J. K. Stanley*, and *C. H. Samans*, Standard Oil Co. (Indiana)

Evidence for Solidification of a Metastable Phase in Fe-Ni Alloys
by *R. E. Cech*, General Electric Co.

Heterogeneous Nucleation of the Martensite Transformation
by *R. E. Cech* and *D. Turnbull*, General Electric Co.

Effects of Alloying Elements on the Electrical Properties of Manganin Type Alloys
by *D. D. Pollock* and *D. I. Finch*, Leeds and Northrup Co.

475° C. Embrittlement of Chromized Coatings on Low-Carbon Steel
by *W. L. Chu*, General Electric Co.

Society for Nondestructive Testing

All Sessions at Hotel Sylvania, Philadelphia

Monday, Oct. 17

9:00 A.M. — Educational Survey

Orientation Lecture
by *Robert C. McMaster*, Ohio State University

Sources of Defects Located by Nondestructive Testing
by *Carl E. Betz*, Magnaflux Corp.

Radiography
by *Royal G. Tobey*, Eastman Kodak Co.

Magnetic Particle Inspection
by *W. E. Thomas*, Magnaflux Corp.

1:30 P.M.—Educational Survey

Penetrant and Eddy Current Testing
by *Hamilton Migel*, Magnaflux Corp.

Ultrasonic Inspection—Reflection Testing
by *John C. Smak*, Sperry Products, Inc.

Ultrasonic Inspection—Resonance Testing
by *Peter K. Bloch*, Branson Instrument Co.

Ultrasonic Inspection—Immersion Testing
by *J. B. Morgan*, Aluminum Co. of America

Evaluation of Indications of Discontinuities
by *James H. Bly*, X-Ray, Inc.

Tuesday, Oct. 18

9:00 A.M. — Production Testing

A High-Powered Industrial Fluoroscopic Tube
by *Donald T. O'Connor*, Machlett Laboratories, Inc.

Three Electronic Measurement Methods for Metallurgy
by *Friedrich Foerster*, Institute Dr. Foerster, Reutlingen, Germany

Eddy-Current Inspection in Aircraft Production Applications
by *Richard Hochschild*, University of California

Field and Laboratory Stress Analysis of Locomotive Components
by *Ludvig Petersen*, Electro-Motive Div., General Motors Corp.

2:00 P.M. — Aircraft Inspection

Management Looks at Nondestructive Testing in Commercial Aircraft Manufacture
by *Paul Allen*, Beech Aircraft

The Relationship of Quality Control to Nondestructive Testing
by *Brig. Gen. William P. Farnsworth*, Office of the Assistant Secretary of Defense

The Application of Nondestructive Testing by a Manufacturer of Military Aircraft
by *W. J. Maloney*, Fairchild Aircraft Co.

Application of Nondestructive Testing in the Manufacture of Aviation Gas Turbine Engines
by *Fred W. Rohde*, Westinghouse Electric Corp.

Wednesday, Oct. 19

9:00 A.M. — Marine Inspection

Radiography of Marine Equipment
by *Willard L. Schwinn* and *Gilbert R. Forrer*, Babcock & Wilcox Co.

Ultrasonic Testing of Ship Plate
by *Howard E. Dickerman*, Portsmouth Naval Shipyard

Nondestructive Testing in Naval Construction
by *William P. Kelley*, Bath Iron Works

Radiography of Welds Using Portable X-Ray Equipment
by *G. W. Leverett, Jr.*, Long Beach Naval Shipyard

Nondestructive Testing in Construction of Aircraft Carrier "Saratoga"
by *John L. Cahill*, New York Naval Shipyard

2:00 P.M. — Annual Meeting and Lester Honor Lecture

Report on Brussels Meeting
by *Gerold H. Tenney*, Chairman, S.N.T. International Relations Committee

de Forest Award (to be announced)
Coolidge Award (to be announced)

The Basis for Standards of Radiation Protection
by *Lauriston S. Taylor*, National Bureau of Standards

Thursday, Oct. 20

9:00 A.M. — Ordnance Inspection

Electromagnetic Radiation for Testing of Ordnance Products
by *Joseph I. Bujes*, Naval Ordnance Test Station

Nondestructive Test Engineering at Frankford Arsenal
by *Maurice J. Smith* and *Alfred J. Wysoczanski*, Frankford Arsenal

Production Radiographic Inspection of Propellants
by *Carl E. Johnson*, Silas Mason Co., Cornhusker Ordnance Plant

Characteristics of a Closed Link Television X-Ray Inspection System
by *Daniel Polansky* and *Edward L. Criscuolo*, Naval Ordnance Laboratory

Betatron Strobo-Radiography
by *R. A. Pulk*, Detroit Arsenal

2:00 P.M. — Casting, Forging and Weld Inspection

Factors Affecting Interpretation of Ultrasonic Indications
by *Robert H. Hafemeister*, Allis-Chalmers Mfg. Co.

Geometry Influence on Ultrasonic Testing of Large Forgings
by *Steve Serabian*, General Electric Co.

Ultrasonic Testing of Rail and Railroad Equipment
by *Erich Martin*, German Federal Railroad, Minden-Westfalen, Germany

Nondestructive Testing of Lead Linings
by *Kempton H. Roll*, Lead Industries Association

Nondestructive Testing of Electrical Forgings
by *F. Howard Oberlin* and *R. H. Leith*, U. S. Steel Corp., Homestead Works

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American Welding Society

All Meetings at Bellevue-Stratford Hotel, Philadelphia

Monday, Oct. 17

10:00 A.M. — Prize Awards and Adams Lecture

2:00 P.M. — CO_2 Gas-Shielded Welding

An Interpretation of Research and Experience in Structural Welding
by *LaMotte Grover*, Air Reduction Sales Co.

Carbon-Dioxide-Shielded Metal-Arc Welding Process
by *Robert J. Keller* and *John P. Koss*, A. O. Smith Corp.

Moisture and Its Effects in Carbon Dioxide Welding of Steel
by *Roger W. Tuthill*, General Electric Co.

Electrode Characteristics for Welding Mild Steel in Atmospheres of Carbon Dioxide by the Consumable-Electrode Gas-Shielded Welding Process
by *Robert D. Mann* and *Julian D. Carey*, General Electric Co.

2:00 P.M. — Resistance Welding

The Behavior of Spot Weld Cross-Section During Loading
by *John F. Rudy*, Wright Air Development Center
Roy B. McCauley and *Robert S. Green*, Ohio State University

Seam Welding Dissimilar Thicknesses of Low-Carbon Steel
by *M. L. Begeman* and *Ernest J. Funk*, University of Texas

Resistance Spot Welding Schedules for Welding Projection Hardware to Mild Steel Sheet and Plate
by *O. K. Barnes*, Westinghouse Electric Corp.

2:00 P.M. — Weldability and Research

Effect of Preheating on Stress-Corrosion Cracking of Steel Weldments
by *E. Paul DeGarmo* and *I. Cornet*, University of California

Heat Treatment of Air Hardening Alloys on Welding
by *John J. B. Rutherford* and *John F. Ewing*, Babcock & Wilcox Co.

The Development of High-Tensile High-Impact Electrodes
by *G. S. Wepfer*, A. O. Smith Corp.

Tuesday, Oct. 18

9:30 A.M. — Weldability and Research

Further Studies of the Hot Ductility of High-Temperature Alloys
by *Ernest F. Nippes* and *Warren F. Savage*, Rensselaer Polytechnic Institute

Influence of Lattice Structure Upon Strength-Ductility-Temperature Relationships
by *Julius Heuschkel*, Westinghouse Electric Corp.

A Welding Test for Gray and Nodular Cast Iron
by *A. L. Schaeffler* and *W. A. Schumbacker*, Allis-Chalmers Mfg. Co.

American Welding Society, Continued

Tuesday, Oct. 18

9:30 A.M. — Structures

Fatigue Strength of Welds in Low-Alloy Structural Steels
by *G. E. Nordmark*, *W. H. Munse*, *J. E. Stallmeyer* and *N. M. Newmark*, University of Illinois

Welding of Structural Steel for Hartford Library
by *Carl L. Kreidler*, Lehigh Structural Steel Co.

Fabrication of Crosshead Beams for the World's Largest Hydraulic Press
by *V. M. Nigriny*, Midvale Co.

9:30 A.M. — Inspection and Testing

Backing Ring Elimination Permits Ultrasonic Testing and Avoids Cracking of Piping Welds
by *Wilfred A. Pollock*, Wisconsin Electric Power Co.

The Gamma Radiographic Control of Welded Transmission Pipe Lines
by *Colin M. C. Bates*, Welding Supervision Ltd.

Radiography in the Jungles of Sumatra, Indonesia
by *Walter W. Offner*, X-ray Engineering Co.

2:00 P.M. — Weldability and Research

The Effect of Microstructure on Notch Toughness and Fracture Morphology—Part II
by *Joseph C. Danko*, *John H. Gross* and *Robert D. Stout*, Lehigh University

Crack Arresting by Overlays of Notch-Tough Weld Metal
by *P. P. Puzak* and *W. S. Pellini*, Naval Research Laboratory

Studies on the Brittle Failure of Tankage Steel Plates
by *M. S. Northup*, *F. J. Feely, Jr.* and *S. R. Kleppe*, Esso Research & Eng. Co.
and *Max Gensamer*, Columbia University

2:00 P.M. — Shipbuilding

Offshore Drilling Barges
by *Robert H. Macy*, Ingalls Shipbuilding Corp.

Building an All-Welded 96-Ft. Twin-Screw Yacht
by *LaMotte Grover*, Air Reduction Co.
and *E. H. Holder*, Ingalls Shipbuilding Corp.

Stress Studies of Various Shaped Welded Doublers in Hatch Corner
by *Yoshio Akita*, Transportation Technical Research Institute
H. Kihara, University of Tokyo
N. Ando, Transportation Technical Research Institute
and *K. Yoshimoto*, Ishikawajima Heavy Industry Co.

2:00 P.M. — Welding Equipment

Characteristics of a Rectifier-Type Constant Voltage Power Supply
by *Jesse W. Pomazal*, Harnischfeger Corp.

Transient Problems When Using Hypersil Transformers in Welding Applications
by *Robert C. Mierendorf*, Square D Co.

Power Sources for Inert-Gas-Shielded Consumable Electrode Welding
by *A. Lesnewich* and *Everett Cushman*, Air Reduction Co., Inc.

Wednesday, Oct. 19

9:30 A.M. — Stainless Steels

Mechanical Properties of Modified Type 347 Weld Deposits
by *Lorin K. Poole* and *R. David Thomas, Jr.*, Arcos Corp.

Hot Cracking of Stainless Steel Weldments
by *P. P. Puzak*, *W. R. Apblett* and *W. S. Pellini*, Naval Research Laboratory

Permeability and Crack Sensitivity of Stainless Welds
by *John L. Lang* and *Charles Wright, Jr.*, Lukens Steel Co.

9:30 A.M. — Welding Electrodes

Metal Powder Electrodes and Their Applications
by *E. DiLiberti*, Air Reduction Sales Co.

Properties and Applications of Low-Hydrogen Iron Powder Electrodes
by *D. C. Smith*, *W. G. Rinehart* and *D. C. Helton*, Harnischfeger Corp.

Effect of Individual Coating Ingredients on Surface Tension of Iron Electrodes
by *Thomas H. Hazlett* and *Earl R. Parker*, University of California

9:30 A.M. — Applications

Selection of Proper Inert-Gas-Shielded Arc Welding Process
by *J. Warden Cunningham* and *Harry A. Huff, Jr.*, Air Reduction Sales Co.

High-Speed Welding of Steel Compressor Cases
by *C. F. Stephenson*, York Grantly Div., York Corp.
and *Robert A. Stone*, Air Reduction Sales Co.

New Surfacing Techniques
by *K. H. Koopman* and *R. S. Zuchowski*, Linde Air Products Co.

2:00 P.M. — Titanium and Molybdenum

Welding of Titanium
by *E. F. Gorman*, Linde Air Products Co.

Resistance Welding Ductile Joints in Commercially Pure Titanium
by *Robert Wickham*, Marquardt Aircraft Co.

Effects of Oxygen on Soundness and Ductility of Molybdenum Welds
by *W. N. Platte*, Westinghouse Electric Corp.

2:00 P.M. — Welding Electrodes

A New Approach to Welding of Alloy Steels With Alloy Fluxes
by *Emmett Smith* and *Paul Jerabek*, Lincoln Electric Co.

Effect of Aluminum Additions to Mild Steel Weld Metal
by *Craig R. Sibley*, Air Reduction Co., Inc.

Effect of Current and Atmospheres on Arc Temperatures
by *George M. Gordon*, *Olga A. Cotter* and *Earl R. Parker*, University of California

2:00 P.M. — Pressure Vessels

Performance of High-Strength Pressure Vessel Steels
by *J. H. Gross* and *R. D. Stout*, Lehigh University

Resistance of Low-Alloy Steel Plates to Biaxial Fatigue
by *C. E. Bowman* and *T. J. Dolan*, University of Illinois

The Practical Approach to the Welding of Stainless Steel Pressure Vessels
by *Frederick H. Clash, Jr.*, Link-Belt Co.

Thursday, Oct. 20

9:30 A.M. — Aluminum

Inert Shielding Gases for Welding Aluminum
by *James D. Dowd*, Aluminum Co. of America

Hydrogen vs. Acetylene vs. Inert Gas in Welding Aluminum Alloys
by *J. Koziarski*, Piasecki Helicopter Corp.

Welding Aluminum to Copper Using Inert-Gas Metal-Arc Process
by *L. A. Cook* and *M. F. Stavish*, Kaiser Aluminum & Chemical Corp.

9:30 A.M. — Piping and Pressure Vessels

Welding of High-Temperature High-Pressure Piping With Chrome-Moly Electrodes
by *Lloyd C. Nesbitt*, Metal & Thermit Corp.

The Application of Inert-Gas Tungsten-Arc Welding to Carbon Steel Pipe
by *F. P. Pilia* and *R. W. Minga*, Linde Air Products Co.

Welding of Pressure Vessels With Automatic Submerged Arc
by *Wilmer W. Weber*, Pfaudler Co.

9:30 A.M. — Applications

Automation of Metal Manufacturing Requires Correct Use of Arc Welding
by *H. O. Klinke*, Taylor-Winfield Corp.

How to Apply Automatic Submerged-Arc Welding
by *Robert Wilson*, Lincoln Electric Co.

Lower Part Cost by Projection Welding
by *C. H. Burgston*, Deere & Co.

Friday, Oct. 21

9:30 A.M. — Brazing

Wettability of Steel With Pure Silver and Silver Brazing Alloys
by *Nikolajs Bredzs*, Armour Research Foundation of Illinois Institute of Technology

Physical Properties of Butt Joints Brazed With BCu, BAg-1, and BAg-3 Filler Metals
by *Grant Hansel, Jr.*, General Electric Co.

Automatic Blade of High-Solidity Axial Flow Fans
by *John B. Hill, Jr.*, Sawyer-Bailey Corp.

9:30 A.M. — Maintenance and Cutting

Effective Welding Circuit Maintenance
by *Donald L. Caldwell*, Caterpillar Tractor Co.

Production Methods for the Fabrication of Rear Axle Housings
by *E. Lommel*, Chevrolet Div., General Motors Corp.

Contour Beveling With the Electronic Tracer
by *Howard B. Cary*, Marion Power Shovel Co., and *R. F. Helmkamp*, Air Reduction Sales Co.

9:30 A.M. — Applications

How to Use Steel Effectively in Machinery
by *Omer Blodgett*, Lincoln Electric Co.

An Application of the Pressure Welding Process to Fabricate Continuous Rail
by *D. C. Hastings*, Richmond, Fredericksburg and Potomac Railroad Co.

Manual Arc Welding of Butt Joints in Crane Rails
by *Ivan Kutuchief*, A. O. Smith Corp.

Metals Division

Special Libraries Association

Meetings at Sylvania Hotel, Philadelphia

Wednesday, Oct. 19

7:00 A.M. — All-day Field Trip to Bethlehem Steel Co. Plants

8:00 P.M. — Metals Division Board Meeting

Thursday, Oct. 20

9:30 A.M. — Indexing Systems in Industrial Libraries

Use of the ASM-SLA System by Industrial Metallurgists
by *E. C. Wallace*, Barber-Colman Co.

Use of the Uniterm Coordinate Indexing System In a large Industrial Concern
by *Robert L. Francisco*, General Electric Co.

Battelle Memorial Institute Subject Index System
by *Robert Gibson*, Battelle Memorial Institute

2:00 P.M. — Powder Metallurgy

Powder Metallurgy Literature
by *Jean Haime*, Fansteel Corp.

Powder Metallurgy With Especial Reference to the Refractory Metals
by *Harry W. Highriter*, Vascoloy-Ramet Corp.

6:30 P.M. — Dinner and Social Hour

Friday, Oct. 21

9:00 A.M. — Field Trip to American Society for Testing Materials

2:00 P.M. — Field Trip to Franklin Institute

What to See at the Metal Show

Exhibitors, Booth Numbers and Descriptions of Products in Ten Subject Categories

Producers of Metals and Alloys; Mill Shapes

INTERNATIONAL NICKEL CO. – whose showing at the National Metal Exposition, year after year, has set a high standard of excellence – plans a double feature which will warrant the attention of visitors. There is not only to be a celebration of the 50th anniversary of Monel Metal, but also the introduction of "Ni-O-Nel", the latest of a long line of improved nickel alloys. This wealth of improved metals and alloys devised and promoted by this energetic organization should be a puzzle to anyone – including American lawmakers – who believes that large corporations with a commanding share of the business inevitably will be allergic to any change in the status quo. Certainly this dictum is disproved by the leadership displayed and innovations promoted by large American firms in the field of metal production (and the word "American" includes Canadian, of course). Ni-O-Nel, by the way, is a 40-21 Ni-Cr alloy with additions of 3% Mo and 1.75% Cu, the latter markedly fortifying the resistance of nickel to sulphurous, sulphuric and phosphoric acids.

Also on exhibit will be some alloy steels and high-temperature alloys vacuum melted by Universal-Cyclops Steel Corp. and by Carboloy Dept. of General Electric Co. As noted in "Critical Points" just a year ago, these firms have installed unique furnaces for producing 1000-lb. ingots of alloy steels which are notably cleaner (and therefore should have better fatigue resistance in anti-friction bearings and springs) and free of dissolved gas like hydrogen (and therefore should be good for the alloy steels heat treated to really high strength which otherwise are subject to delayed brittle failure under steady tension). Likewise, some of the new "superalloys" for extra high-temperature service contain considerable percentages of metals which are chemically reactive and – like many magnetic and electronic alloys – must be vacuum melted to develop their maximum possibilities. Carboloy will feature in its exhibit a new alloy of this sort called Carboloy 1570, a 20-28-38 Cr-Ni-Co alloy with 7% tungsten and 4% titanium, suitable for jet-engine service. Vacuum-melted Carboloy 1570 has rupture strength of 12,500 psi. in 1000 hr. at 1500° F., whereas the well-known S-816 alloy, when melted in air, has a rupture strength of only 8000 psi.

Such new things should not blind the visitor to the workhorses of metallurgy – those well-known metals and alloys which have served us so long. Not content to rely upon a prospective world shortage in copper to maintain a satisfactory price and market situation, even if limited to the rapidly expanding electrical uses, American Brass Co. has for years been studying production, alloying and fabrication problems of copper and its ancient alloys, and has produced a series of specialties which are real engineering metals – such as the "Everdurs" and the silicon bronzes. More recent products on display will be thin sheet and strip which rely on ultra-fine and uniform grain size for ease in mass production, such as "Duraflex", a phosphor bronze with

superior endurance limit; a new 6% cupronickel for color TV screens with microscopic holes uniformly spaced; and "Formbrite", which cuts the costs of finishing in half.

Many composite and prefinished metals are now available and are responsible for economies in production, as will be shown by at least four exhibitors, Metals & Controls Corp., American Nickeloid Co., Bart Mfg. Corp., and Sharon Steel Corp. Some of the most useful products are electro-clads on steel; here, of course, advanced technology in the producer's plants must insure coatings which cling tenaciously and have satisfactory formability. Several combinations of copper, brass, nickel or chromium on basic materials such as aluminum, steel and zinc are available in high finishes and in various crimps and striped designs, suitable for the manufacture of attractive and economical ware. (Sharon Steel Corp. will show "Sharonart", which is steel strip finished between rolls etched to mottled designs.) Other materials are more truly composite metals, such as overlays, edgelays or single or double inlays, where two or even more metals in thicker proportions are welded together. Metals & Controls Corp. will show these in great variety and demonstrate the present industrial application of methods first developed some 40 years ago for "gold-filled" jewelry.

Finally we come to the "new" metals, things which many visitors will look at first, rather than finally. Titanium Metals Corp. of America and Titanium Alloy Mfg. Div. of National Lead Co. will both have interesting things to tell the visitor about the virtues of titanium and its alloys – especially about the progress recently made in getting rid of some exasperating "bugs", the new strong alloys, and the metal's availability in quantity and various mill shapes. It still has the unique combination of lightness, strength, ductility, and corrosion resistance which should bring it into uses other than in fast aircraft, jet engines, and missiles. Zirconium is also now available for those who can use it, as well as beryllium alloys, from Beryllium Corp. Chromium – while not exactly a new metal to industry in the form of alloys and ferro-alloys – is newly available in massive, quite pure form. Four sessions are scheduled among the technical sessions where ductile chromium and its high alloys will be discussed, bringing to the public ear for the first time extensive investigations sponsored by U.S. Army Ordnance.

Almost at the other end of the atomic scale from titanium in weight is molybdenum, a metal



Not Counting the Sidewalk Superintendents, It Takes Four Men Ten Minutes to Remove a 48-Sq. Ft. Panel of Stainless Steel From Its Packing Case and Fix It to the Structure. It weighs 100 lb.; 48 sq. ft. of 12-in. masonry weighs 3½ tons

whose exceptional qualities have been described in the series of articles in *Metal Progress* just finished, and which will be further demonstrated to the public by Climax Molybdenum Co.

Then there are all the metals newly important in the coming age of atomic power, an era so prominently in the public eye as the result of the international conference in Geneva. There seems to be a sense of urgency here. Several American producers of ferrovanadium make a uranium concentrate from their ores or are in the uranium mining business. Of course, uranium must be sold to the Government, but the Atomic Energy Commission has now set a price on refined or enriched uranium suitable for fuel for power plants. Aside from the power generators now owned and operated by the Government, one large station near Pittsburgh is already under construction to feed power into a public service system. Other very large, privately financed plants are in advanced stage of design. Even more urgent interest is evident in lands abroad – particularly England. Consequently such booths as those occupied by Atomic Energy of Canada, Ltd., General Dynamics Corp., Nuclear Research Corp., and Visioneering Co., Inc., will be busy during Exposition week.

Classified List of Exhibitors and Booth Numbers — Metal Producers

Steels (Plain and Alloy)

Allegheny Ludlum Steel Corp.—120
Alloy Precision Castings Co.—1715
American Cast Iron Pipe Co.—1830
American Electro Metal Corp.—1843
American Nickeloid Co.—1275
Climax Molybdenum Co.—421
Coated Coil Corp.—1630
Cold Metal Products Co.—338
Copperweld Steel Co.—310
Disston & Sons, Inc., Henry—1753
Eaton Manufacturing Co.—1553
Enamelstrip Corp.—1630
Firth Sterling, Inc.—740
Industrial Research Lab., Inc.—2053
International Nickel Co., Inc.—309
Kolcast Industries, Inc.—1561
Ryerson & Son, Inc., Joseph T.—931
Sharon Steel Corp.—1719
Superior Tube Co.—1470
Universal-Cyclops Steel Corp.—1520
Westinghouse Electric Corp.—1510

High-Temperature Alloys

Allegheny Ludlum Steel Corp.—120
Alloy Precision Castings Co.—1715
American Cast Iron Pipe Co.—1830
Chromalloy Corp.—2154
Driver Co., Wilbur B.—515
Driver-Harris Co.—534
Firth Sterling, Inc.—740
General Alloys Co.—204
General Electric Co.
Carboloy Dept.—1540
International Nickel Co., Inc.—309
Kolcast Industries, Inc.—1561
Precision Tube Co., Inc.—1167
Superior Tube Co.—1470
Universal-Cyclops Steel Corp.—1520
Westinghouse Electric Corp.—1510

Stainless & Corrosion Resistant Steels

Allegheny Ludlum Steel Corp.—120
Alloy Precision Castings Co.—1715
American Cast Iron Pipe Co.—1830
Bart Manufacturing Corp.—1058
Chromalloy Corp.—2154
Coated Coil Corp.—1630
Disston & Sons, Inc., Henry—1753
Driver Co., Wilbur B.—515
Firth Sterling, Inc.—740
General Alloys Co.—204
International Nickel Co., Inc.—309
Kolcast Industries, Inc.—1561
Murray Co., Inc., A. B.—2111
Superior Tube Co.—1470
Westinghouse Electric Corp.—1510
Whitehead Metal Products Co., Inc.—1344

Light Metals and Alloys

Alloy Precision Castings Co.—1715
American Brass Co.—211
American Nickeloid Co.—1275
Bendix Aviation Corp.,
Eclipse Pioneer Div.—1616
Bendix Aviation Corp.,
Pioneer Central Div.—1525
Brush Beryllium Co.—437
Driver Co., Wilbur B.—515
Exomet, Inc.—2128
Precision Tube Co., Inc.—1167
Rolle Mfg. Co., Inc.—1620
Sall Metals Co., George—1062
Superior Tube Co.—1470
Titanium Metals Corp.
of America—624
United Wire & Supply Corp.—2009
Westinghouse Electric Corp.—1510
Whitehead Metal Products Co., Inc.—1344

Copper, Nickel and Other Nonferrous Metals and Alloys

Alloy Precision Castings Co.—1715
American Brass Co.—211
American Nickeloid Co.—1275
American Non-Gran Bronze Co.—1950
Bart Manufacturing Corp.—1058
Beryllium Corp.—618
Brush Beryllium Co.—437
Climax Molybdenum Co.—421
Cooper Metallurgical Associates—2048
Driver Co., Wilbur B.—515
Driver-Harris Co.—534
International Nickel Co., Inc.—309
Malayan Tin Bureau—1772
Metals & Controls Corp.—1440
Murray Co., Inc., A. B.—2111
National Lead Co.—130
Olin Mathieson Chemical Corp.—524
Precision Tube Co., Inc.—1167
Pressco Castings & Mfg. Corp.—2028
Sall Metals Co., George—1062
Superior Tube Co.—1470
Tin Research Institute, Inc.—439
Titan Metal Mfg. Co.—341
United Wire & Supply Corp.—2009
Westinghouse Electric Corp.—1510
Whitehead Metal Products Co.—1344

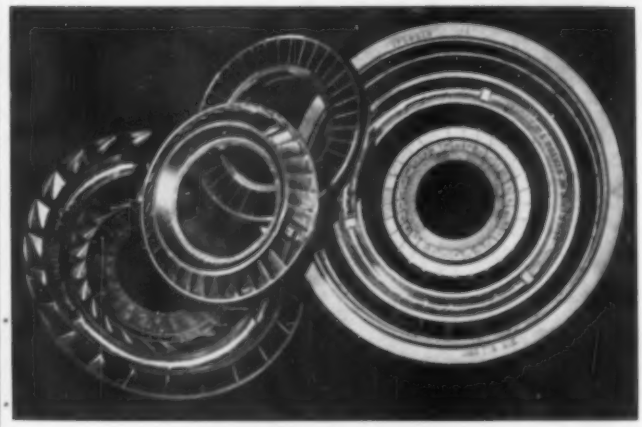
Parts and Components

MANY a metals engineer has complained that the sole function of designers is to create shapes and forms of metal components that cannot be produced economically. Fortunately, exhibitors of components like castings, weldments, stampings and forgings have been working with the metals engineer and each year develop some new fabrication method to outwit the designers' schemes.

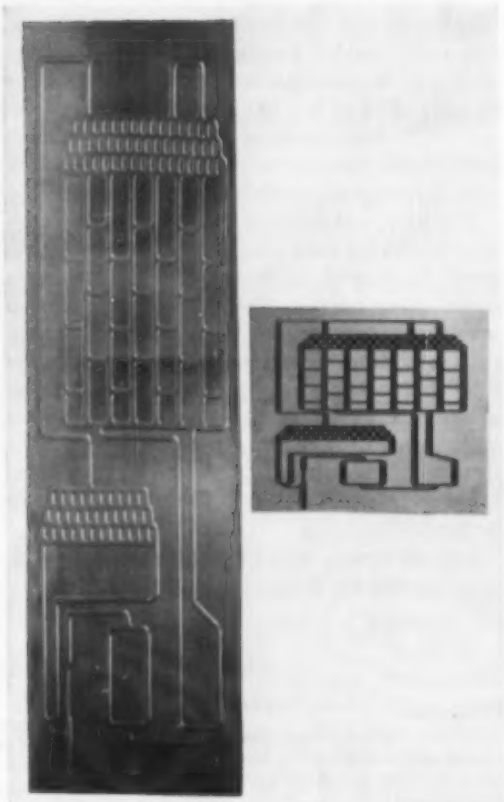
One of the most ingenious developments to be exhibited this year is the Roll Bond process for making any pattern of tubing within a single sheet of metal. The system was developed by the Western Brass Div. of Olin Mathieson for refrigerator evaporator plates but is expected to be used in other applications where heat exchange is a problem. When used to make evaporator plates retooling costs were cut from $50,000 to $50 and retooling time from six weeks to one week.

Two flat pieces of aluminum or copper are cut to size and cleaned. The pattern that will become tubing and other passages is transferred by the silk screen process to one of the flat sheets. The "paint" used to apply the pattern is a stop-weld material that prevents the surface from bonding to another piece of metal under heat and pressure. The two sheets are placed face to face to form a metal "sandwich" and are spot welded to maintain their relative positions.

The unit is hot rolled for bonding; subsequent cold rollings reduce the homogeneous sheet to proper thickness. Rolling elongates the pattern several times. The key to the operations is to plan a silk screen pattern, which, when elongated, will result in perfectly proportioned pat-



Heavy-Duty Torque Converter Elements Cast to Close Tolerance With the Antioch Process by Morris Bean & Co.



Before and After Views of an Evaporator Plate Made by the Roll Bond Process. On the right is the original silk screen pattern painted with stop-weld, which is rolled out and inflated to the finished shape

terns. After roll bonding, the fused material is annealed. Everything bonds except the area where the stop-weld pattern has been applied. One end of the elongated metal plate is then trimmed to bare the lead-in end of the stop-welded pattern. A needle, much like that used to inflate a football, is inserted into this end and hydraulic pressure inflates the nonwelded design. Stop-weld areas become passageways which are flushed out, cleaned and dried. The result is a labyrinth of dilated passageways which correspond exactly to blueprint specifications.

Any pattern that can be drawn on a piece of paper can be reproduced as tubing within a metal sheet. As many as six sheets of metal can be bonded at one time. Even complicated parallel or multiple tubes, running at right angles in two or more layers, can be made with complete efficiency. Also, it is said to be impossible for tubes within the plates to develop leaks.

Solid complex components are more widely used than those with holes intentionally included and the variety of casting methods and their specific advantages for such production will be featured by the various foundry exhibitors. Pressco Casting and Mfg. Corp., for example, will exhibit its regular line of brass and bronze pressure die castings and permanent mold castings. For such items as plumbing hardware, valve bodies and closed pump impellers, Pressco recently installed equipment to produce permanent mold castings using shell-molded cores. This method is reported to reduce costs substantially.

Light alloy castings will be featured by a number of exhibitors and the choice of casting method is wide open. Bendix Foundries will display both aluminum and magnesium castings made by five different methods – plaster, die, sand, shell and permanent molding. Representatives will be glad to help you select the one most appropriate for the castings you need. For fluid flow, wave-guides and tire molds Morris Bean and Co. will show a number of representative "Antioch process" aluminum castings held to very close tolerances. This method (described in *Metal Progress*, February 1953, p. 97) employs a mixture of gypsum and sand for the mold that gives thin-walled castings of complex shape.

The Al-Fin Div. of the Fairchild Engine and Airplane Corp. will have examples of "metallurgically bonded bimetallic products", aluminum and magnesium castings bonded to other metals. Many of the applications for this process are still under security classification but enough commercial components will be shown to indicate the range of possible applications.

Precision Metalsmiths, Inc. believes that castings would be used much more widely if they could be proved satisfactory before making a costly investment in tooling. Their product is investment castings but they plan to use their exhibit to show how to make, inexpensively, the small number of castings needed to prove the application in advance of tooling. The scheme is to machine polystyrene prototype patterns from which investment molds can be made. Information on how to handle the polystyrene will be available.

Iron and steel castings of all sizes and complexities will be shown by a number of exhibitors, as usual. Lynchburg Foundry Co. is now in production in its new $1,250,000 shell molding foundry and will display many of the ductile and gray iron castings that have been made. Dodge Steel Co. is also proud of its expansion this year by the addition of a finished products division for machining and assembling both on the steel castings it produces and on other components that its customers need.

Not to be outdone by the expansion in foundries, Consolidated Industries, Inc., specialists in aircraft quality forgings, will promote their recent installation of larger and heavier forging equipment to handle steel, aluminum, titanium and even zirconium on either an experimental or production basis.

When the part has two parallel sides, Joseph T. Ryerson & Son, Inc. will furnish steel plate accurately flame-cut to close tolerances and to practically any desired shape. The 8-torch, Oxygraph flame-cutting machine, guided by electric eye, will be demonstrated in operation.

Classified List of Exhibitors and Booth Numbers

Forgings

Allegheny Ludlum Steel Corp.—120
Consolidated Industries, Inc.—963
Drop Forging Association—1278
International Nickel Co., Inc.—309
Kerns Co., L. R.—1250
Metal Improvement Co.—2239
National Cored Forgings Co., Inc.—431
Titan Metal Mfg. Co.—341
Titanium Metals Corp. of America—624

Castings

Al-Fin Div., Fairchild Engine & Airplane Corp.—1810
Allegheny Ludlum Steel Corp.—120
Alloy Precision Castings Co.—1715
American Brake Shoe Co.—352
American Cast Iron Pipe Co.—1830
American Non-Gran Bronze Co.—1950
Arwood Precision Casting Corp.—1327
Bean & Co., Morris—452
Bendix Foundries—1616
Casting Engineers, Inc.—841
Central Foundry Div., General Motors Corp.—945
Coast Metals, Inc.—1907
Day Engineering Co., Inc.—1671
Dodge Steel Co.—1443
Driver-Harris Co.—534
Eclipse Pioneer Div., Bendix Aviation Corp.—1616
Engineered Precision Casting Co.—1269
Fab-Alloy Co. Div., John Crowley Boiler Works—2116
Gries Reproducer Corp.—240
Hitchiner Mfg. Co., Inc.—926
Howard Foundry Co.—208
International Nickel Co., Inc.—309
Janney Cylinder Co.—1263
Kolcast Industries, Inc.—1561
Lynchburg Foundry Co.—709
National Lead Co.—130
National Precision Casting Corp.—1768
Pioneer Central Div., Bendix Aviation Corp.—1525
Precision Metalsmiths, Inc.—1761
Pressco Casting and Mfg. Corp.—2028
Rolle Manufacturing Co., Inc.—1620
Shenango-Pen Mold Co., Centrifugal Castings Div.—650
Tickle Engineering Works, Inc., Arthur—1808
Titan Metal Mfg. Co.—341
Universal Castings Corp.—1856
Yale & Towne Mfg. Co., Powdered Metal Products Div.—1557

Powder Metals and Parts

American Electro Metal Corp.—1843
Amplex Div., Chrysler Corp.—610
Baldwin-Lima-Hamilton Corp.—1954
Cooper Metallurgical Associates—2048
General Electric Co., Carboloy Dept.—1540
Plastic Metals Div., National-U.S. Radiator Corp.—1330
Stokes Machine Co., F. J.—1302
Titanium Metals Corp. of America—624
United Wire & Supply Corp.—2009
Yale & Towne Mfg. Co., Powdered Metal Products Div.—1557

Tubing

Allegheny Ludlum Steel Corp.—120
American Brass Co.—211
American Cast Iron Pipe Co.—1830
Babcock & Wilcox Co., Tubular Products Div.—241
Bart Manufacturing Corp.—1658
Fab-Alloy Co. Div., John Crowley Boiler Works—2116
Howard Foundry Co.—208
International Nickel Co., Inc.—309
Murray Co., Inc., A. B.—2111
Ohio Seamless Tube Div., Copperweld Steel Co.—310
Titanium Metals Corp. of America—624
United Wire & Supply Corp.—2009

Stampings

American Nickeloid Co.—1275
Fab-Alloy Co. Div., John Crowley Boiler Works—2116
Falstrom Co.—651
Heintz Mfg. Co.—1758
Kaupp & Sons, C. B.—1201
Kerns Co., L. R.—1250
National Lead Co.—130
Olin Mathieson Chemical Corp., Western Brass Div.—524
Phoenix Products Co., Metal Spinning Div.—1672
Ryerson & Son, Inc., Joseph T.—931
Stimpson Co., Inc., Edwin B.—411
Titanium Metals Corp. of America—624
United Shoe Machinery Corp.—735
U. S. Plywood Corp.—1871
Waldes Kohinoor, Inc.—1466

Mill, Forging and Foundry Equipment and Supplies

VACUUM still seems to be the magic word in melting and processing equipment and virtually all vacuum equipment manufacturers have new installations and an improved line to talk about at the Metal Show. A good example of the reason for such widespread interest is the article on p. 126, which indicates the remarkable improvement in metal properties that can be realized by vacuum treatment.

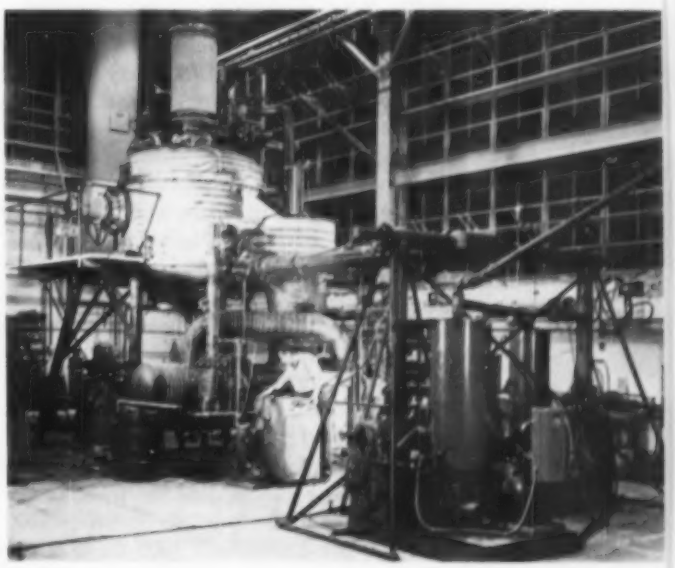
Consolidated Vacuum Corp. will feature the "first semicontinuous high-vacuum melting and casting furnace" shown in the accompanying photograph; it went into production in the Carboloy plant at Detroit this year. Its furnace capacity is 1000 lb. and it is expected to produce 120,000 lb. of vacuum melted metal per month. Three separate vacuum chambers make up the complete unit. While the heat is being melted, the charging chamber may be sealed off and the charge for the next heat prepared. Ingot molds are stored in the third vacuum chamber below the furnace so that the ingots may be poured in a vacuum and then removed while another heat is being melted. The Carboloy furnace is also a "modular" type designed so that its capacity may be changed to match demands by interchange of certain components. Consolidated Vacuum hastens to point out that the first such "modular" unit was installed at the metallurgical development laboratory of Westinghouse early this year. It will eventually be used to melt 1000-lb. heats also but now has only 350 lb. capacity.

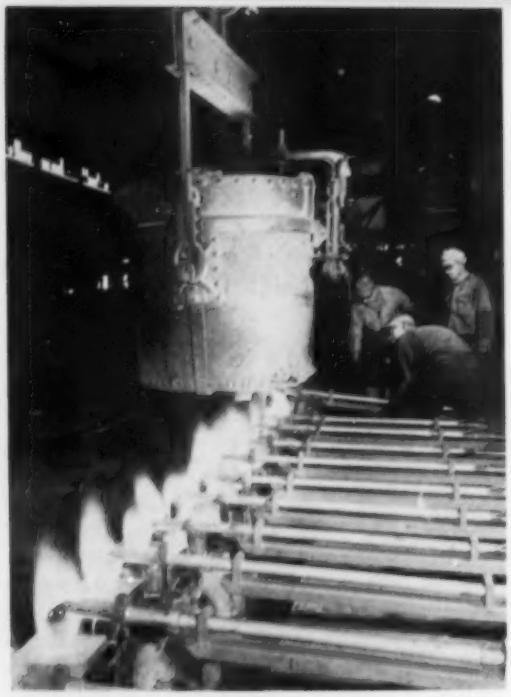
F. J. Stokes Machine Co. is also promoting its modular furnace recently installed at Thompson Products, Inc. It too is capable of producing 1000-lb. melts but is currently being used for 200-lb. heats. Stokes is most proud of its new Ring-Jet diffusion and booster pumps that, size for size, pump 10 to 100% faster than any other for a given heat input. Speaking of pumps, the Metal Show will provide a perfect opportunity for comparison shopping since you'll see the Stokes Ring-Jet, Consolidated Vacuum's new type KS-16000 that removes 1,000,000 micron-liters of gas per second (12.5 lb. of air per hr.), and Kinney's Model KMB two-stage mechanical booster pump. The Kinney pump is designed to cope with sudden outbursting of gases encountered in vacuum purification and treatment of metals and metal coatings.

For complete vacuum-melting furnaces, sizes will range from the 1000-lb. furnaces of Stokes and Consolidated to the 10-kg. Balzers furnace to be shown by American Electro Metal Corp. Ajax Electrothermic, manufacturer of induction heating and melting equipment, installed a vacuum unit at Universal-Cyclops Steel Co. this year and will be very happy to discuss your requirements with you. For conventional melting of either ferrous or nonferrous alloys, Ajax Electrothermic will display its standard line and emphasize its recent installation at Sandusky Foundry of some of the largest induction melting furnaces that have ever been built.

For nonferrous melting Ajax Engineering Corp. will exhibit a recent model of its Ajax-omatic automatic pouring-type furnace. The advantages of this new twin-inductor low-frequency induction furnace include the possibility of melting metal in the furnace without interrupting

Semicontinuous High-Vacuum Melting and Casting Furnace Designed and Built for Carboloy by Consolidated Vacuum Corp.





Airco Gas Hot Topping System in Use at Allegheny Ludlum Steel Corp.

the continuous automatic discharge of accurately repeated amounts of molten metal into a die-casting machine or mold where the fuel is natural gas. Continental Industrial Engineers has supplied several aluminum melters provided with automatic continuous casting machines so that furnaces operate quite automatically, forming pigs which are cooled, stamped, dumped and delivered to the trucks for transport. Each special batch of metal is automatically stamped for further identification.

Selas Corp. has just announced a new continuous furnace for melting aluminum alloys for castings, a cooperative development with Monarch Aluminum Mfg. Co. It is a relatively small tunnel furnace that slopes downward from the input to the output end. Ingots are loaded at the upper end, and automatically pushed lengthwise under a roof of Selas Duradiant burners. The melting rate and the pouring temperature are controlled by regulating the speed of the ingots through the furnace and the fuel input to the burners. Molten aluminum flows continuously through an opening near the lower end of the furnace directly into a pouring ladle.

Its most obvious advantage to the furnace operator (and to the editors who inspected it on a hot summer day) is the tremendous improvement in working conditions in comparison to the reverberatory furnaces normally used. In the Selas-Monarch unit designed for pouring 2000 lb. aluminum per hour, about 1000 lb. is in the furnace at any time and only a few hundred pounds is actually molten. For the same production with conventional reverberatory furnaces, about 15,000 lb. of aluminum must be held liquid at about 1400° F. Such a pool of molten metal makes it uncomfortable to stand within about 25 ft., whereas the outside walls of the new furnace are cool to the touch.

By eliminating the large liquid reserve and improving control of heating, fuel consumption is greatly reduced. Performance records at Monarch show an over-all gas consumption of 1.9 cu. ft. per pound of aluminum melted in the continuous melting furnace as against 3 cu. ft. per pound in the most efficient reverberatory batch furnace. Deducting fuel requirements for the warm-up period, the ratio falls to 1.1 cu. ft. of gas per pound melted. The best advertised gas consumption in any other type of furnace doing the same work is approximately 1.7 cu. ft. per pound. Quality of the aluminum castings produced is reported to be superior because there is little or no dross formed that could produce inclusions. In addition, chemical composition can be more closely controlled because of the small mass of molten metal and the short time that it remains liquid.

Both Reed-Prentice Corp. and American Die Casting Machinery Co. plan to show the latest in high-speed equipment for mass production. The Reed-Prentice display will be a "cold-chamber" die-casting machine for aluminum and magnesium with an interchangeable high-pressure plunger gooseneck for die casing zinc. On the cold-chamber models, plunger speed has been increased to 10,000 in. per min. to produce extra-dense aluminum and magnesium castings. American Die Casting Machinery Co. will feature its new, low-cost machine which will handle up to 700 shots per hour for castings ranging in size from 1 oz. to 2½ lb.

Hot topping equipment is not usually displayed at the Metal Show but Air Reduction Co. is especially proud of the recent installation at Allegheny Ludlum's Dunkirk plant of its new gas hot topping system. Ingot yield of high-alloy steels has been increased by more than 4%, yet installation and equipment costs were a fraction of the expenditure for other heating methods that produce comparable results. With the Airco system, the steel in a shallow hot-top refractory is kept molten by means of an oxygen-natural-gas flame while the ingot cools. Thus, virtually all the metal in the hot top flows into the ingot, leaving a minimum of excess metal.

Classified List of Exhibitors and Booth Numbers — Mill and Foundry

Melting Furnaces and Refractories

Ajax Electrothermic Corp.—1619
Ajax Engineering Corp.—1619
American Electro Metal Corp.—1843
American Positive Grip Vise Corp.—2047
Consolidated Vacuum Corp.—836
Continental Industrial Engineers, Inc.—1701
Hones, Inc., Charles A.—1804
Lindberg Engineering Co.—230
Selas Corp. of America—1601
Stokes Machine Co., F. J.—1302
Surface Combustion Corp.—304

Forging Equipment

Gas Appliance Service, Inc.—1932
Hauck Mfg. Co.—1921
Continental Industrial Engineers, Inc.—1701
Surface Combustion Corp.—304

Mill Equipment

Air Reduction Co.—1750
Continental Industrial Engineers, Inc.—1701
Eriez Mfg. Co.—1917
Industrial Research Laboratory, Inc.—2053
Stanat Manufacturing Co., Inc.—1355

Foundry Equipment and Processes

Arcair Co.—1066
Continental Industrial Engineers, Inc.—1701
Eriez Mfg. Co.—1917
Exomet, Inc.—2128
Kinney Mfg. Div., New York Air Brake Co.—1171
Liquid Carbonic Corp.—1478
Ransohoff, Inc., N.—1608

Die-Casting Machines

A.-B.-C.-Die Casting Machine Co.—1877
American Die Casting Machinery Co.—1571
Reed-Prentice Corp.—602

Alloying and Refining Agents (Ferro-Alloys)

Cooper Metallurgical Associates—2048
Exomet, Inc.—2128
Sall Metals Co., George—1062
Vanadium Corp. of America—816

Machining, Forming, Tooling

PRODUCERS of toolsteels will be much better represented in Philadelphia than in recent expositions and will talk service, rather than revolutionary new analyses. Maybe this is just as well, because the classification printed in *Metal Progress* for July 15, 1954, shows no less than 88 "principal" types, of which 16 are made by the majority of producers and widely stocked in warehouses. Much emphasis will therefore be given to *choice* (to avoid misapplication), the *design* (to avoid early tool failure), and proper *handling* of a well-chosen, well-designed tool. One trend might be mentioned, especially in the field of forming tools, toward higher content of vanadium carbide for maximum wear resistance.

One entirely new tool material is the cemented oxide-base cutting tool material to be shown by the Carboloy Dept. of General Electric Co. A major advantage is that it contains no tantalum, tungsten or cobalt, which are not only expensive but in relatively short supply, especially during times of emergency.

The new material is brittle and more susceptible to cracking than carbides but it provides good tool life at speeds of 2000 ft. per min. With a feed of 0.005 in. and depth of cut of 0.100 in. at that speed, the tool lasts 27 min. in machining 1045 steel annealed to Brinell 170.

Firth Sterling, Inc., will introduce the "first low-cost throwaway toolholder", the Firthite Thrift-tool. It contains fewer component parts than any other such tool and is available in sizes as small as ⅛ in. By utilizing preground throwaway Firthite inserts which eliminate grinding and offer a minimum of six cutting edges, this tool is extremely well suited to a variety of metal-working operations.

Forged high speed steel tools guaranteed to outlast and outperform all other high speed steel tools will be shown by the Modern Tools Div. of the Nelco Tool Co. The tools are hand forged so that the grain structure of the blank coincides with the contour of the tool, and cutting is done with the side grain which has better resistance to normal operating stresses. They are reported to have better impact strength, wear resistance and more uniform hardness than conventional tools.

Chatter resistant boring bars produced by the Fry Tool Mfg. Co. will be displayed by the Electro Arc Sales Co. Vibration and chatter have been eliminated by hollowing the inside of a steel bar and packing it with lead pellets in heavy grease. The inner core is cut at a specific contour designed to eliminate vibration without sacrifice of bar strength. The bar is reported to be so "dead" that much higher speeds can be used for both rough and light finishing cuts.

Electro Arc will also show its improved metal disintegrators in operation, cutting hardened metal for fast production and high accuracy. Jiffy Tool Supply Co., Inc. will exhibit its new low-cost disintegrator reported to be available at one-tenth the cost of competitive machines for similar applications where broken taps, drills, reamers and screws must be removed without

distortion to the workpiece. The new unit is unique in that it is the only disintegrator head that operates at 120 strokes per second without electronic tubes, rectifiers or condensers.

For cutting mild steel sheet up to 8-gage and stainless up to 10-gage, Fenway Machine Co., Inc. will introduce its new nibbler, said to be the only portable tool of this type available. Sieburg Industries will show its specialized machine, Tensil Kut, designed for accurate and rapid preparation of tensile specimens from sheet metals. It can be used for materials as thin as 0.002 in. and the machined edge shows no indication of cold work. The finish cut on the specimen edge can be as light as 0.0005 in. and the high speed of cutting – 20,000 rpm. – makes the individual "bites" practically infinitesimal.

Best Mfg. Co. calls its versatile drill press "a tool of a 1000 uses". Model No. 75 with capacity up to ⅝ in. has 16 selections of feeds and speeds and can be used for such jobs as sandwich drilling of tubes. By push-button control the drill can be made to approach the work fast, drill at preselected feed through the first wall, move rapidly to the lower wall and then drill slowly through it. It uses a mechanical feed and can be set at any position or angle.

Abrasive cutting techniques will be demonstrated at the American Chain & Cable Co. booth in a cooperative display of two of its divisions, Campbell Machine and Allison. The Allison Co., manufacturer of abrasive cutting wheels, was acquired this year to provide better service to the metalworking industry. Campbell machines and Allison wheels will be shown in operation.

Classified List of Exhibitors and Booth Numbers

Toolsteels and Tool Materials

Allegheny Ludlum Steel Corp.—120
Disston & Sons, Inc., Henry—1753
Firth Sterling, Inc.—740
General Electric Co., Carboloy Dept.—1540
Nelco Tool Co., Inc.—1163
Vanadium-Alloys Steel Co.—104

Cut-Off Equipment

Allison Co.—1420
Campbell Machine Div., American Chain & Cable Co., Inc.—1420
Fab-Alloy Co., Div., John Crowley Boiler Works—2116
Kearney & Trecker Corp., Walker-Turner Div.—1450
Manco Mfg. Co.—1471
Rockwell Mfg. Co., Delta Power Tool Div.—1530
Stone Machinery Co., Inc.—551
Wells Mfg. Corp.—730

Machine Tools and Accessories

Acme Tool Co.—1051
American Positive Grip Vise Corp.—2047
American Pullmax Co., Inc.—1427
Atlas Press Co.—1349
Buck Tool Co.—537
Chicago Tool & Engineering Co.—1654
Crane Packing Co.—1567
Dumore Co.—1539
East Shore Machine Products Co.—1756
Electro Arc Sales Co.—2242
Elox Corp. of Michigan—1027
Engelberg Huller Co.—1073
Fenway Machine Co., Inc.—2247
Lempco Products, Inc.—560
Mead Specialties Co.—1872
Modernair Corp.—959
Nelco Tool Co., Inc.—1163
Pedrick Tool & Machine Co.—741
Porter-McLeod Machine Tool Co., Inc.—1367
Rockwell Manufacturing Co., Delta Power Tool Div.—1530
Sieburg Industries—1876
Stanley Electric Tools Div.—2123
Taylor Dynamometer & Machine Co.—965
Tech-Pacific Corp.—2167
Turco Products, Inc.—1319
Wells Mfg. Corp.—730

Cutting and Forming Oils and Lubricants

Griffith-Raguse and Co., Inc.—1727
Gulf Oil Corp.—1414
Houghton & Co., E. F.—724
Johnson's Wax—750
Kerns Co., L. R.—1250
Oakite Products, Inc.—1767
Pennsylvania Salt Mfg. Co.—1272
Shell Oil Co.—1749
Sun Oil Co.—922
Swan-Finch Oil Corp.—1662
Texas Co.—734

Presses and Brakes

American Pullmax Co., Inc.—1427
Baldwin-Lima-Hamilton Corp.—1954
Cleveland Punch & Shear Works Co.—1739
Diamond Machine Tool Co.—2124
Fab-Alloy Co. Div., John Crowley Boiler Works—2116
Fawick Airflex Div., Fawick Airflex Corp.—507
Franklin Control Corp.—2165
Service Machine Co.—1358 and 1640
Precision Welder & Flexopress Corp.—1158
Stokes Machine Co., F. J.—1302
Wales-Strippit Corp.—1210

Punches and Dies

Allegheny Ludlum Steel Corp.—120
Cleveland Punch & Shear Works Co.—1739
Fab-Alloy Co. Div., John Crowley Boiler Works—2116
General Electric Co., Carboloy Dept.—1540
Heintz Mfg. Co.—1758
National Lead Co.—130
Standard Die Set Manufacturers, Inc.—1675
Wales-Strippit Corp.—1210

Portable and Bench Tools

Acme Tool Co.—1051
American Positive Grip Vise Corp.—2047
Best Mfg. Co.—1268
Black & Decker Mfg. Co.—1707
Chicago Tool & Engineering Co.—1654
Diesel Power, Inc.—2150
Dumore Co.—1539
Electro Arc Sales Co.—2242
Green Instrument Co.—2148
Griffith-Raguse and Co., Inc.—1727
H & H Research Co.—1051
Jiffy Tool Supply Co., Inc.—2140
Lapeer Mfg. Co.—706
Lempco Products, Inc.—560
Lufkin Rule Co.—805
Manco Mfg. Co.—1471
New Hermes Engraving Machine Corp.—1273
Pneuma-Serve, Inc.—640
Pedrick Tool & Machine Co.—741
Rockwell Manufacturing Co., Delta Power Tool Div.—1530
Skil Corp.—1980
Starrett Co., L. S.—1720
Tech-Pacific Corp.—2167
Thor Power Tool Co.—731
Waldes Kohinoor, Inc.—1466
Weatherhead Co.—717

Precision Welder and Flexopress Corp. will have two versatile stamping presses in operation, Model C-30, the fully automatic 30-ton Flexopress, and Model C-15 with 15-ton capacity. Both are equipped with air friction clutch, integral roll feed and variable speed control.

A new multiple-motion powder metal press of 50 tons capacity for making complex, multiple-level parts and parts with inserts will be introduced by the F. J. Stokes Machine Co. The new press, Model 640, is a high-speed precision machine that is simple to adjust and requires relatively short set-up time. It is reported to save cost by simpler tooling, quick press adjustment, and maintenance-free design; furthermore, parts can be produced by powder metallurgy which had never before been considered economical by this method.



Tensil Kut, a New Machine for Preparation of Sheet Metal Tensile Specimens. Sieburg Industries, Inc.

Heat Treating

Since World War I heating elements for most electric furnaces have been made from nickel-chromium wire or narrow strip bent into shape and fastened to the furnace walls. The alloy has high electrical resistance and sufficient oxidation resistance for economical service life. In controlled-atmosphere furnaces, its service life is increased so that electrical furnaces can be easier to maintain than gas-fired furnaces in which the gases of combustion are excluded by expensive mufflers. Unfortunately, the richer atmospheres used for carburizing and carbonitriding tend to deposit soot on the elements and furnace walls. Since soot conducts electricity, it can cause short circuits between strands of the element or between the elements and the metal shell of the furnace.

An entirely new type of element developed especially to eliminate this problem will be featured at the Metal Show by the Lindberg Engineering Co. It is called Corrtherm and consists of large corrugated sheets of nickel-chromium alloy that practically cover the furnace walls. Its secret is that applied voltage is so low that leakage is practically impossible. Besides eliminating short circuits caused by soot deposits, the voltage cannot even be felt by the operator if he should accidentally contact the elements during loading or unloading. Transformers used to provide the low voltages are similar to those developed by Lindberg for induction melting of nonferrous metals.

Installation and replacement are extremely simple since the corrugated sheets are hung from alloy hooks extending through the roof. The corrugations strengthen the element and increase its resistance, and can be so spaced as to vary the heat release along the length to compensate for heat loss near the door or the incoming cold charge. An additional advantage is that in forced-convection furnaces, where high-temperature fans force the hot gases through the charge, the elements act as a direction baffle, heating the gases at the same time.

In areas where electricity is cheaper than other fuels, it is expected that fuel-fired furnaces will be converted to electricity by installation of the Corrtherm element. However, gas is cheaper than electricity in many United States industrial centers and selection of furnace type will continue to be based on how much quality production can be obtained for each dollar spent.

An indication of the importance of fuel costs in furnace selection was the announcement earlier this year of a new line of gas-fired Homocarb furnaces by Leeds & Northrup. These are vertical, batch-type units identical with other Homocarb furnaces except for method of firing.

Burners produce a long flame that wraps around the retort so that the retort acts as a single radiant tube with uniform heat distribution. Continuous, automatic regulation of the carbon content of the furnace atmosphere is provided.

A more striking indication of the importance of gas for industrial heating will be the combined exhibit of nine members of the American Gas Association. Equipment shown will range from small laboratory burners by the American Gas Furnace Co. to the large "Top Hat" furnace used in steel and nonferrous mills which can be displayed (by Continental Industrial Engineers, Inc.) only in a scale model. An unusual exhibit will be the joint effort of two of the A. G. A. group, American Gas Furnace Co. and Metalwash Machinery Corp.; it will show a completely automatic continuous heat treating installation. In this "in-line" unit, the charge is automatically fed into an A. G. F. Model 230 reciprocating furnace, through the furnace into the quench tanks, from the quench to a washing machine and then through a tempering furnace.

The Selas Corp. exhibit will feature machine

Classified List of Exhibitors and Booth Numbers

Electric Furnaces

Ajax Electric Co.—1619
Ajax Electrothermic Corp.—1619
Continental Industrial Engineers, Inc.—1701
Day Engineering Co., Inc.—1671
Drever Co.—1972
Electric Furnace Co.—334
Harper Electric Furnace Corp.—1815
Hevi Duty Electric Co.—808
Ipsen Industries, Inc.—420
Leeds & Northrup Co.—1822
Lindberg Engineering Co.—230
Sentry Co.—635
Upton Electric Furnace Co.—1867
Westinghouse Electric Corp.—1510

Induction Heaters

Ajax Electrothermic Corp.—1619
Ecco High Frequency Corp.—630
Electric Arc, Inc.—1650
Hobart Brothers Co.—1020
Induction Heating Corp.—1242
Lepel High Frequency Laboratories, Inc.—1256
Lindberg Engineering Co.—230
Machlett Laboratories, Inc.—2049
Magnethermic Corp.—1740
Scientific Electric—1279
Tocco Div., Ohio Crankshaft Co.—1509
Westinghouse Electric Corp.—1510

Fuel-Fired Furnaces and Special Heating Equipment

American Gas Association—1910
American Gas Furnace Co.—1914
Carlingo Commodities Corp.—1310
Continental Industrial Engineers, Inc.—1701
Day Engineering Co., Inc.—1671
Drever Co.—1972
Electric Furnace Co.—334
Fab-Alloy Co. Div., John Crowley Boiler Works—2116
Gas Appliance Service, Inc.—1932
Gas Machinery Co.—1942
Hauck Mfg. Co.—1921
Hones Inc., Charles A.—1804
Industrial Heating Equipment Co.—631
Ipsen Industries, Inc.—420
Kemp Mfg. Co., C. M.—1801
Leeds & Northrup Co.—1822
Lindberg Engineering Co.—230
Metalwash Machinery Corp.—1924
Platecoil Div., Tranter Mfg., Inc.—1777
Selas Corp. of America—1601
Stock, Inc., Alvin M.—1757
Surface Combustion Corp.—304
Westinghouse Electric Corp.—1510

Vacuum Furnaces

Ajax Electrothermic Corp.—1619
American Electro Metal Corp.—1843
Consolidated Vacuum Corp.—836
Continental Industrial Engineers, Inc.—1701
Day Engineering Co., Inc.—1671
Fab-Alloy Co. Div., John Crowley Boiler Works—2116
Hevi Duty Electric Co.—808
High Vacuum Equipment Corp.—817
Kinney Mfg. Div., New York Air Brake Co.—1171
Naresco Equipment Corp.—1577
Optical Film Engineering Co.—1067
Stokes Machine Co., F. J.—1302

Industrial Ovens

American Gas Association—1910
Continental Industrial Engineers, Inc.—1701
Day Engineering Co., Inc.—1671
Ransohoff, Inc., N.—1608
Surface Combustion Corp.—304

Atmosphere Preparation Equipment

American Gas Association—1910
Continental Industrial Engineers, Inc.—1701
Day Engineering Co., Inc.—1671
Drever Co.—1972
Electric Furnace Co.—334
Hevi Duty Electric Co.—808
Ipsen Industries, Inc.—420
Leeds & Northrup Co.—1822
Lindberg Engineering Co.—230
Lithium Co.—1901
Surface Combustion Corp.—304
Westinghouse Electric Corp.—1510

Quenching Equipment and Mediums

American Cyanamid Co.—530
American Gas Furnace Co.—1914
Audubon Wire Cloth Corp.—1850
Brown Fintube Co.—1933
Cambridge Wire Cloth Co.—1839
Cincinnati Sub-Zero Products—970
Cities Service Petroleum, Inc.—453
Continental Industrial Engineers, Inc.—1701
Drever Co.—1972
Electric Furnace Co.—334
Fab-Alloy Co. Div., John Crowley Boiler Works—2116
Heatbath Corp.—1362
Houghton & Co., E. F.—724
Ipsen Industries, Inc.—420
Leeds & Northrup Co.—1822
Park Chemical Co.—330
Shell Oil Co.—1749
Surface Combustion Corp.—304
Swan-Finch Oil Corp.—1662
Swift Industrial Chemical Co.—1975

Supplies, Trays, Refractory Parts

American Brake Shoe Co., Electro Alloys Div.—352
American Cyanamid Co.—530
Audubon Wire Cloth Corp.—1850
Brown Fintube Co.—1933
Cambridge Wire Cloth Co.—1839
Continental Industrial Engineers, Inc.—1701
Driver-Harris Co.—534
Fab-Alloy Co. Div., John Crowley Boiler Works—2116
General Alloys Co.—204
Park Chemical Co.—330

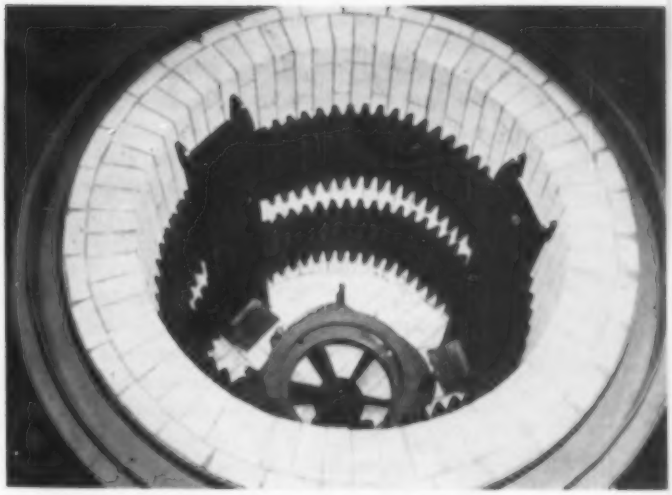
Commercial Heat Treating Service

Drever Co.—1972
Fab-Alloy Co. Div., John Crowley Boiler Works—2116
Metallurgical, Inc.—218
Metlab Company—1047

brazing, galvannealing, fast heating of large steel sections and automatic heating for automatic forging. Automatic heating equipment supplied to Chambersburg Engineering Co. for use in the fully automatic "Cecomatic" forging process will be shown. Selas high-speed heating furnishes bar stock or cut stock at desired forging temperature to permit production rates of up to 1000 forgings per hour.

For nonferrous billets, Magnethermic will have on display its full-scale 2500-lb. per hr. Model CSC heater enclosed in plexiglas. It is a complete 60-cycle induction heating unit; the capacitors, contactor, top switch, transformers and auxiliary control are all mounted within the frame. A different type of a packaged unit was introduced this year by Lepel High Frequency Laboratories. It combines a high-frequency induction heating generator with a refrigerating water recirculator. It can be moved about the plant to any location where power is available.

A comparative newcomer to the heat treating field is vacuum annealing. It became necessary when large quantities of titanium parts were found to be contaminated with embrittling hydrogen and not acceptable for service in aircraft. Many tons of such discarded material has been recovered by vacuum annealing in furnaces of the type to be shown by High Vacuum Equipment Corp. During the annealing cycle hydrogen is reduced from between 200 and 400 parts per million to 30 to 70 ppm. with a corresponding increase in strength and ductility.



Lindberg Corrtherm Heating Elements in Pit-Type Vertical Carburizing Furnace

Temperature Indicators and Fuel Controls

Two years ago in the Metal Show issue of *Metal Progress*, Minneapolis-Honeywell Regulator Co. used a two-page advertisement entitled "Transistors in Instrumentation — When?" At that time its Brown Instrument Div. had been studying possible applications of new circuits and transistor types for five years and Walter P. Wills, director of research, indicated that although a "tubeless" electronic instrument was theoretically possible, much more work was necessary before transistors could be expected to provide the safety and reliability needed in process control instruments.

Each October our fond hopes for the announcement of a line of transistor-containing vest-pocket size temperature controllers have been shattered, but this year there is some encouragement from Consolidated Vacuum Corp. with announcement of the first thermocouple gage for vacuum measurement using a printed circuit. Designated as TG-029, the gage is compact, portable and, because of the printed circuit, is priced considerably lower than conventional single-station models. For measurement of vacuum, it uses a thermocouple with cold junction at the temperature of the tube case and the other junction within the tube heated at constant rate by a stabilized electric current. Since the temperature of the heated junction varies with the heat loss due to gaseous conduction, and pressure determines the rate of conduction, values of pressure are read directly from the specially calibrated voltmeter.

A more conventionally designed monitor for vacuum metallurgists is the new mass spectrometer to be shown by Consolidated Engineering Corp. It is used to analyze the atmosphere in vacuum melting furnaces, either for continuous

monitoring of a single component or for repetitive multicomponent analysis.

Continuous measurement and control of the carburizing potential of furnace atmosphere could probably be managed with the mass spectrometer but Ipsen Industries, Inc. and Surface Combustion Corp. prefer simple instruments based on measurement of dew point. Ipsen's Carbotronik unit (see *Metal Progress*, July 1954, p. 98) uses indicators to check both furnace temperature and the dew point of the furnace atmosphere. It automatically coordinates the two to give any desired carbon potential between 0.20 and 1.25%. Surface Combustion also uses the dew-point method for its Autocarb controller. For heat treaters who have standardized on pneumatic controls, Surface has introduced a new pneumatic Autocarb with all the features of the regular electronic unit.

The Foxboro Co. will show a new instrument, the "EMF-Pneumatic Transmitter", which also converts electrical measurements into proportional pneumatic pressures. A transducer assembly actuates a flapper nozzle magnetically and produces an air relay output proportional to the original measurement. Another new item that Foxboro will display is an electro-magnetic flowmeter for measuring waste effluent, slurries and corrosive liquids. It consists of a non-magnetic flow tube with an insulating liner containing flush-mounted metallic electrodes and surrounded by an a-c. electromagnet. When conductive liquid passes through the tube, an alternating voltage is set up between the electrodes, which varies linearly in proportion to the rate of the flow. Lead wires from the electrodes transmit this voltage output to a recorder.

No drastic changes have been announced for temperature indicating instruments although practically all the exhibitors have added models that are a little more versatile and serviceable. Bristol Co., for example, will feature its new Electronic Dynamaster Time-Temperature Program Controller that controls temperatures according to a predetermined schedule of changing values. The schedule is fixed by the contour of a transparent plastic cam. Since cams of different contours are easily cut and interchanged, a single controller can be used for any number of different programs.

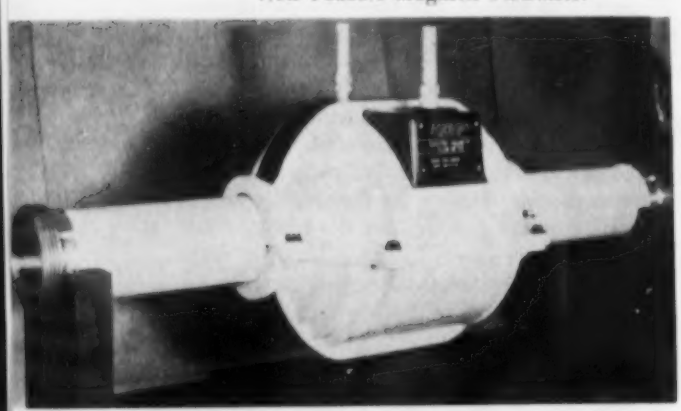
The Tempil® Corp., which has been showing its line of temperature-indicating crayons, paints and pellets at the Show for many years, has also expanded its range of products. In addition it has added new indicators in the range of 400 to 500° F. to permit closer temperature control for such jobs as preheating for welding. Visitors to the booth will be offered sample pellets.

Under the general heading of fuel control must be included the instrumentation required to handle the fuel in nuclear reactors. Very little information had been released until the recent "Atoms for Peace" Conference in Geneva, where a nuclear reactor simulator designed and built by Leeds & Northrup Co. was shown. Control is centered around an analog computer that solves continuously the complete differential equation representing the kinetic operation of the reactor. This simulator will not be available for the show and Leeds & Northrup instead will feature its Speedomax H line of instruments which were introduced a year ago.



Thermocouple Vacuum Gage Designed Around a Printed Circuit by Consolidated Vacuum Corp.

New Foxboro Magnetic Flowmeter



Classified List of Exhibitors and Booth Numbers — Instruments

Pyrometers

Bristol Co.—1658
Carlingo Commodities Corp.—1310
Foxboro Co.—1377
Illinois Testing Laboratories, Inc.—919
Leeds & Northrup Co.—1822
Peerless Electric Co.—1155
Pyrometer Instrument Co., Inc.—1439
Wheelco Instruments Div., Barber-Colman Co.—809

Gas Samplers and Analyzers

American Electro Metal Corp.—1843
Consolidated Engineering Corp.—836
Consolidated Vacuum Corp.—836
Continental Industrial Engineers, Inc.—1701
Exomet, Inc.—2128
Foxboro Co.—1377
Ipsen Industries, Inc.—420
Leeds & Northrup Co.—1822
Lindberg Engineering Co.—230
Surface Combustion Corp.—304

Indicators, Recorders and Controllers

Bristol Co.—1658
Electric Arc, Inc.—1659
Foxboro Co.—1377
General Electric Co., Carboloy Dept.—1540
Illinois Testing Laboratories, Inc.—919
Leeds & Northrup Co.—1822
Peerless Electric Co.—1155
Pyrometer Instrument Co., Inc.—1439
Stock, Inc., Alvin M.—1757
Taylor Instrument Co.—966
Tempil Corp.—1533
Weston Electrical Instrument Corp.—2224
Wheelco Instrument Div., Barber-Colman Co.—809

Automatic Fluid and Pressure Controls

Bristol Co.—1658
Foxboro Co.—1377
Waukee Engineering Co.—1239
Weston Electrical Instrument Corp.—2224

Welding and Associated Processes

Joining metals by making a casting between them is sometimes called welding and sometimes called soldering or brazing but whatever you call it there can be no doubt that people are inventing more and better ways of doing it all the time. Each year many new processes or marked improvements of old processes are to be found at the National Metal Exposition.

This year advances in welding include spot welding from one side using an arc, higher-speed submerged-arc welding, machines that supply either alternating or direct current at the turn of a switch, a new use of an old gas for protective atmospheres, and some new welding, brazing, and hard facing rods.

When you see the new "C-Omatic" welding at the A. O. Smith Corp. booth you can find out how to save money by using carbon dioxide instead of helium or argon to shield the arc. This is for the popular inert-gas-shielded metal arc. To make the same amount of weld 60 cu. ft. per hr. of argon is used at a cost of $4.80; 70 cu. ft. per hr. of helium costs $4.20; only 30 cu. ft. per hr. of carbon dioxide is needed at a cost of $0.30 per hr. Work that will pass X-ray inspection can be made with this process.

The old argument between the backers of alternating-current and direct-current equipment can now be settled. The Lincoln Electric Co. is showing a line of combined alternating and direct-current welding machines called "Idealarc". It lets the customer use what works best in each application. This machine has three more settings than the ordinary welder. This will put more responsibility on the supervisor or metallurgical control group because operators trained to set the current and select straight or reverse polarity or alternating current will have to be told how to set the three-position arc control switch.

To extend further the use of automatic submerged-arc welding into the field of low-alloy steels, Lincoln Electric Co. offers fluxes which add alloying elements to welds made with mild steel rod, individually compounded for each job. Up to 7% chromium, 4% molybdenum, 1½% vanadium or 7% nickel can be added to the joint from the flux. By combining alloy flux and alloy rod one can get even higher alloy content.

Babcock and Wilcox Co. has announced a new automatic submerged-arc process called "I^2RT". The main difference from the standard submerged arc is that in the new process most of the energy melts the rod instead of large quantities of base metal. This is done by using smaller rod and higher current with a long distance between the contact shoe and the arc. I^2RT is the term for electric energy that is converted to heat



Lincoln Welding Machine With Arc Control, and Alternating and Direct Current Selector

in a resistor. The rod is heated by this energy almost to the melting point before it enters the arc. Using 2½ times as much energy as present welding processes, the new method can melt five times as much weld metal.

Westinghouse Electric Co. has a complete automatic rod coating and packaging plant (*Metal Progress*, July 1955, p. 116) which will probably have its effect on welding-rod cost.

People who have to weld many kinds of metal will welcome the new Inco-Rod "A" which can be used to arc weld anything from mild steel to 18-8 stainless and high-nickel alloys. It is also recommended for combinations such as mild steel to Monel metal, stainless steel, or Inconel.

By placing tungsten carbide and other hard surfacing materials in a tube and coating the tube, Coast Metals, Inc. has produced a wide range of hard surfacing rods for arc or torch application. They also have some nickel-base brazing alloys which can be applied to stainless steel and other metals on all controlled-atmosphere furnaces. Melting points run from 1790 to 1910° F. Another brazing material is "Phoson" exhibited by United Wire and Supply Corp., especially made for refrigeration tube joints. A restful thing to watch is the Selas Corp. "packaged brazing unit" which will be in operation. The operator merely loads and unloads the machine while it does all the work of making burners the same as in actual production. Selas offers these units designed to each customer's requirements. Those interested in brazing will also want to see the high-speed induction brazing and soldering unit in operation at the display of Scientific Electric.

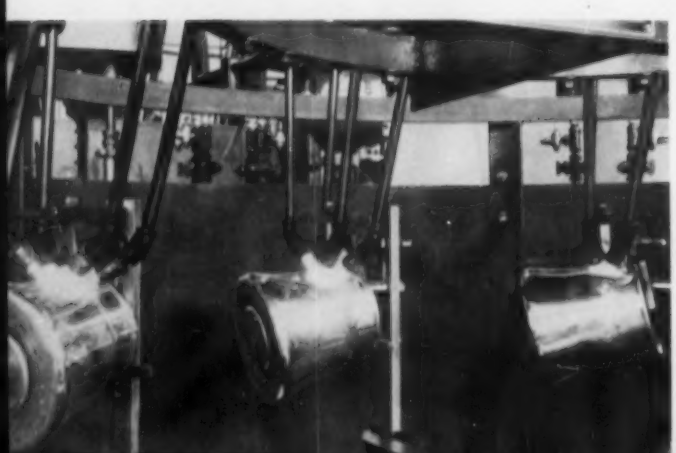
A machine that forms and welds cylinders or tubes is the latest addition to the resistance welders that will be shown by Banner Welder Inc. National Torch Tip will exhibit the new military standard torch, in its display of cutting, welding, and flame hardening equipment.

An example of increased speed will be a demonstration of semi-automatic electric gouging by air-electric torch (Arcair Co.). Steel, brass, and aluminum are among the metals that can be cut and grooved. An electric arc melts the metal and an air jet blows it away. The semi-automatic machine which is being demonstrated at this show for the first time makes a much smoother job than the former manual torch.

The American Electrical Heater Co. has a pencil-type electric soldering iron with the element in the tip, that weighs only 6 oz.! Pneuma-Serve Inc. is showing an "automated" screw feeder and screwdriver. Screws are dumped in a small hopper, picked up, set in the right position, and sent speeding through a plastic tube so the operator can drive them as fast as a power screwdriver can work.

The Heli-Coil Corp. has added a left-hand design to their already extensive line of wire thread inserts. These are used to strengthen tapped holes in aluminum, and as reducers to fit bolts in oversized holes.

Industrial Research Laboratory Inc. will show its "Channelette" which is a ¾-in. formed channel of "microstructural" section. It is crimped on either as an edge strengthener or as a fastener.



Selas Automatic Gas Brazing Machine Brazing Spouts on Aluminum Coffee Pots

Classified List of Exhibitors and Booth Numbers — Welding

Flame Welding Equipment and Supplies

Air Reduction Sales Co.—1750
Arcair Co.—1066
Coast Metals, Inc.—1907
Graham Mfg. Corp.—2031
Linde Air Products Co.—1375
Liquid Carbonic Corp.—1478
National Torch Tip Co.—2149
National Welding Supply Association—1961
Smith Welding Equipment Corp.—1714
Weldtronic Company—1955

Arc Welding and Electrodes

Air Reduction Sales Co.—1750
American Brass Co.—211
American Electro Metal Corp.—1843
Arcair Co.—1066
Babcock & Wilcox Co.—241
Cam-Lok Div., Empire Products, Inc.—1827
Coast Metals, Inc.—1907
Eutectic Welding Alloys Corp.—1225
Harnischfeger Corp.—1657
Hobart Brothers Co.—1020
International Nickel Co., Inc.—309
Linde Air Products Co.—1375
Lincoln Electric Co.—231
Liquid Carbonic Corp.—1478
Metal & Thermit Corp.—153
National Welding Supply Association—1961
Phoenix Products Co., Metal Spinning Div.—1672
Reid Avery Co.—1519
Smith Corp., A. O.—1842
Vickers Electric Div., Vickers, Inc.—1771
Westinghouse Electric Corp—1510

Resistance Welding

Aro Spotwelders Corp.—1316
Banner Welder, Inc.—1251
National Welding Supply Association—1961
Sciaky Bros., Inc.—946
Scientific Electric—1279
United Welders, Inc.—521
Weltronic Co.—1955
Westinghouse Electric Corp.—1510

Brazing and Soldering

Air Reduction Sales Co.—1750
Alpha Metals, Inc.—955
American Brass Co.—211
American Electrical Heater Co.—2060
American Electro Metal Corp.—1843
Coast Metals, Inc.—1907
Eutectic Welding Alloys Corp.—1225
Gas Appliance Service, Inc.—1932
Linde Air Products Co.—1375
National Lead Co.—130
National Welding Supply Association—1961
Scientific Electric—1279
Selas Corp. of America—1601
Tocco Div., Ohio Crankshaft Co.—1509
United Wire & Supply Corp.—2009

Gas and Arc Cutting

Air Reduction Sales Co.—1750
Arcair Co.—1066
Eutectic Welding Alloys Corp.—1225
Heath Engineering Co.—969
Linde Air Products Co.—1375
Liquid Carbonic Corp.—1478
National Torch Tip Co.—2149
National Welding Supply Association—1961
Ryerson & Son., Inc., Joseph T.—931

Fasteners

Acme Steel Co.—1965
Cam-Lok Div., Empire Products, Inc.—1827
Chain-Lock Process Co.—2169
Du Pont de Nemours & Co., E. I.—1457
Eaton Mfg. Co.—1553
Goodrich Co., B. F.—641
Graham Mfg. Corp.—2031
Heli-Coil Corp.—617
Pneuma-Serve, Inc.—640
South Chester Corp.—1443
Stimpson Co., Inc., Edwin B.—411
Tinnerman Products, Inc.—1467
Townsend Co.—1371
United Shoe Machinery Corp.—735

Positioners

Harnischfeger Corp.—1657
National Welding Supply Association—1961
Reid Avery Co.—1519

Thermit Welding

Exomet, Inc.—2128
National Welding Supply Association—1961

Cleaning and Finishing Equipment

Ultrasonic vibration to increase efficiency in cleaning metal parts was introduced at the National Metal Exposition in 1953 simultaneously by three firms: Circo Equipment Co., Detrex Corp. and the Tocco Div. of Ohio Crankshaft Co. The number of applications is still growing (July 1955, p. 99) and at least three additional manufacturers of ultrasonic equipment will show their latest developments.

The General Ultrasonics Co. will display its Sonicells, ultrasonic generators which can be used in practically any conventional cleaning installation whether the cleaner is a detergent, acid or caustic. In addition, two new applications for ultrasonics will be shown in operation. Soniplate, by rapid scavenging and replacement of exhausted electrolyte at the liquid-metal interface, is reported to increase plating rates up to 50 times the rate by conventional methods. Soniplate also cleans as it plates. Sonistrip is the application of ultrasonics to pickling and descaling of ferrous or nonferrous metals. It has reduced pickling time in some applications from 1 hr. to about 90 sec.

Branson Ultrasonic Co. has a new line of ultrasonic generators hermetically sealed in stainless steel so that they can be used in a wider range of cleaning mediums. Four models will be shown with transducer areas from 10 to 500 sq.in. The Pioneer-Central Div. of Bendix Aviation Corp.



Torsion Test Specimens of Porcelain Enameled Iron With Conventional Ground Coat (Top) and Parker Pre-Namel 410 (Bottom)

will display its magnetostrictive ultrasonic cleaners for use with water-detergent mixtures in aviation and atomic energy applications.

Spray Painting – Metal Show visitors who look for information on paint spraying will be swamped with material from at least five exhibitors of equipment, if the advance publicity is a valid indication. All use different systems, all are the "most economical and efficient", and fortunately all will be displayed so that you can compare the merits of each process.

Scientific Electric and Ransburg Electro-Coating Corp. will each show electrostatic paint spraying equipment in operation. Scientific Electric will exhibit its new "Ionic Guns with Atomic Nozzles" used not only for painting but recently proved successful in spray-coating wire goods with plastisol. Ransburg will have two demonstrations; its No. 2 electrostatic spray process disk loop will be painting a variety of small parts, and a "split-pattern atomizing bell" which produces two vertical, elongated spray patterns will also be shown.

Spee-Flo Corp. and Bede Products Corp. are promoting the hot-spray process. "Airless atomization paint spraying" will be shown by Bede; in this process the necessary hydraulic pressure is produced by vapor pressure of the heated volatile solvent. Advance information on the Spee-Flo process is not too detailed but it indicates that major improvements are a new coil-less heat exchanger and a trouble-free centrifugal circulating pump. The DeVilbiss Co. display will also include hot-spray equipment but the company will emphasize its new catalyst spray gun for uniform mixing of resins and catalysts.

Chromate Conversion Coatings – Painting of nonferrous metals requires a good undercoating and a large number of chromate conversion coatings have been developed for that purpose. Such coatings provide both good initial paint adhesion and additional corrosion resistance. Because of this resistance to corrosion and the fact that their color can be varied over a wide range, they are now used as finishes for aluminum, zinc, cadmium, magnesium, silver and copper-base alloys. Most manufacturers offer a family of solutions under specific brand names; Allied Research Products, Inc. uses "Iridite"; the Chemical Corp., "Luster-on"; and Heatbath Corp., "Durocoat". The compositions are proprietary but each exhibitor will be glad to point out the specific advantages of his line.

Preparation of steel for porcelain enameling until now has required a costly and time-consuming ground coat. A new material, Parker Pre-Namel 410, will be featured by the Parker Rust Proof Co. as the key to a method of applying porcelain enamel directly to steel. With it a good-quality product is obtained at a saving of one to three cents per square foot of enameled area. A similar material, Parker Pre-Namel 420, is used to prepare aluminum for enameling.

The Swift Industrial Chemical Co. will display its line of blackening compounds and acid additives. Maximum density of the oxide finish is promised as the result of a Swift process called "Activanium Blending", which means that several different oxides are included in the compounds.

Precision barrel finishing with aluminum oxide chips was formerly unsatisfactory because particles of the oxide impregnated the metal surfaces and turned them black. About four years ago the Lord Chemical Corp. introduced the first of its compounds to eliminate this difficulty and since then has added more than 25 additional chemicals for specialized tumbling applications. Included in its line are the necessary materials for use in deburring, fine polishing, burnishing, coloring, rust prevention and degreasing.

Classified List of Exhibitors and Booth Numbers — Finishing

Blast Cleaning

American Steel Abrasives Co.—1162
Clayton-Sherman Abrasives Co.—1162
Clementina Ltd.—609
Dings Magnetic Separator Co.—2132
Globe Steel Abrasive Co.—1162
Pangborn Corp.—1032
Steel Shot Producers, Inc.—1162
Vacu-Blast Co., Inc.—811
Wheelabrator Corp.—1402

Pickling, Cleaning, Degreasing

Blakeslee & Co., G. S.—1819
Branson Ultrasonic Co.—831
Circo Equipment Co.—1378
Curtiss-Wright Corp.—246
Detrex Corp.—1205
Diversey Corp.—844
Drever Co.—1972
Eclipse Pioneer Div.,
Bendix Aviation Corp.—1616
Fab-Alloy Co. Div.,
John Crowley Boiler Works—2116
Gasway Corp.—1477
General Ultrasonic Co.—1063
Haveg Corp.—2055
Houghton & Co., E. F.—724
Kelite Corp.—2019
Metalwash Machinery Corp.—1924
Oakite Products, Inc.—1767
Pennsylvania Salt Mfg. Co.—1272
Phillips Mfg. Co.—512
Pioneer Central Div.,
Bendix Aviation Corp.—1525
Ramco Equipment Corp. Div.,
Randall Mfg. Co., Inc.—550
Ransohoff, Inc., N.—1608
Swift Industrial Chemical Co.—1975
Turco Products, Inc.—1319

Electroplating and Metallizing

Chemical Corp.—967
Chromalloy Corp.—2154
Commercial Filters Corp.—1419
Consolidated Vacuum Corp.—836
General Ultrasonic Co.—1063
Heatbath Corp.—1362
Minnesota Mining and Mfg. Co.—1668
Metallizing Co. of America—2061
Platecoil Div.,
Tranter Manufacturing, Inc.—1777
Stokes Machine Co., F. J.—1302
Swift Industrial Chemical Co.—1975
Tickle Engineering Works, Inc.,
Arthur—1808

Grinding Wheels, Abrasives

Allison Co.—1420
American Steel Abrasives Co.—1162
Globe Steel Abrasive Co.—1162
Griffith-Raguse and Co., Inc.—1727
Production Machine Co.—1339
Rockwell Manufacturing Co.,
Delta Power Tool Div.—1530
Thor Power Tool Co.—731
Timesavers, Inc.—2250

Rust Preventives, Paints and Painting Equipment

Allied Research Products, Inc.—962
American Chemical Paint Co.—518
Bede Products Corp.—1361
Binks Mfg. Co.—1807
Chemical Corp.—967
Commercial Filters Corp.—1419
Detrex Corp.—1205
DeVilbiss Co.—751
Gasway Corp.—1477
Griffith-Raguse and Co., Inc.—1727
Heatbath Corp.—1362
Houghton & Co., E. F.—724
Kerns Co., L. R.—1250
Lake Chemical Co.—506
Minnesota Mining and Mfg. Co.—1668
Oakite Products, Inc.—1767
Parker Rust Proof Co.—1549
Pennsylvania Salt Mfg. Co.—1272
Ransburg Electro-Coating
Corp.—1983
Scientific Electric—1279
Shell Oil Co.—1749
Spee-Flo Corp.—2012
Swift Industrial Chemical Co.—1975

Brushing, Buffing and Polishing

Black & Decker Mfg. Co.—1707
Griffith-Raguse and Co., Inc.—1727
Hammond Machinery Builders,
Inc.—1453
Lord Chemical Corporation—1059
Osborn Mfg. Co.—718
Production Machine Co.—1339
Skil Corp.—1980
Steel Shot Producers, Inc.—1162
Swift Industrial Chemical Co.—1975
Thor Power Tool Co.—731
Timesavers, Inc.—2250

Testing and Inspection Equipment

In this section of the classification are included devices for determining mechanical and physical properties, such as tension machines and hardness testers, equipment for chemical and scientific laboratories, metallurgical microscopes, gages for measuring size and shape, and methods for making other nondestructive tests. The last two mentioned are looming large in modern mass production, since they are basic to statistical control methods, and are readily adaptable to shop use, right in the machine lines. Another trend is the adaptation of methods, once thought to require laboratory surroundings, to more rough-and-ready shop conditions.

As a matter of fact, each visitor to the National Metal Exposition will carry with him, in his own eyes, a more magnificent pair of inspection instruments than ever constructed by man, and a large fraction of the instrument field, as above described, consists of devices for helping the eyes see into constricted openings, emphasizing surface defects so they can be seen clearly, magnifying surfaces so that fine detail can be seen and recording such appearances for future reference, and "watching" the performances of distant or hidden operations.

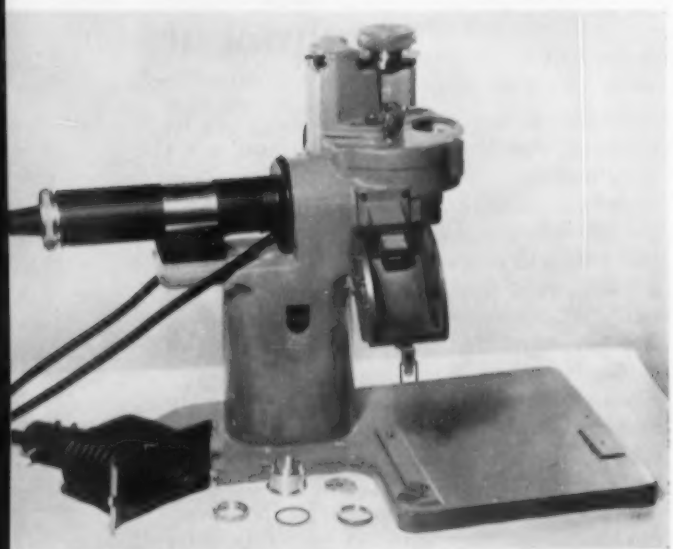
Some of these operations, auxiliary to the human eye, require intricate electronic and electrical hook-ups, often confusing in the extreme to the mere metallurgist. However, one device is simple – a "borescope" marketed by the American Cystoscope Makers, Inc. A cystoscope is far

more familiar to the medical profession than to laymen, for it is used to examine interior conditions through small openings in the body – a small sighting tube with appropriate lens systems and a tiny light at the end. This is an ideal scheme for examining interior surfaces of drilled or bored holes, and two new borescopes now are available, one for use with fluorescent magnetic particles or penetrants, and the other arranged with a 50-power microscope to examine chromium-plated cylinders for porosity.

Microscope builders also have new ideas. Hot, even molten, metals can be examined up to 100 diameters by the AO Thermal Microscope on display in American Optical Co.'s booth. A "microfurnace" is built in so that its radiations will not harm the optical system. Valuable information about phase changes can be recorded *in color* by attaching a Cine-Kodak to the eyepiece.

A sharp competition will be noted among methods for radiographic inspection. X-rays had a monopoly in this field up to a few years ago, and progressed along the line of higher and higher voltages for greater and greater thicknesses of metal. Then came beta and gamma radiation from artificial sources – particularly the isotopes Co^{60} and Ir^{192} produced by exposure of the stable metals to intense radiation in uranium reactors. As Atomic Energy of Canada, Ltd., will tell you, a tiny speck of these metals contained in a ¾-in. capsule approaches an ideal source of radiation – short focal distance, short exposure, clear definition, maximum portability, independence of external power. An equivalent amount of radium costs 30 times as much as Co^{60}, whose radiation equals in penetrating power a 2,000,000-volt X-ray machine. The iridium isotope emits "soft" radiation, approximating a 600,000-volt X-ray and is best used for examining the light metals or for thin sections of the heavy ones. Health hazards are avoided by staying some distance away from the containers, and Mitchell Radiation Products Corp. will exhibit long-handled dollies and 5-ft. manipulators.

"Norelco" Inverted Spectrograph, Made by North American Philips Co., Inc. for Truly Nondestructive Analysis of Metals, Powders and Liquids



To meet competition from radioactive elements, Triplett & Barton Inc. will present its "Tri-Ind-X" unit, a new design of portable X-ray unit based on equipment proven by nearly 10 years' use in cramped spaces about ship structures and engine rooms. The tube and coolant are contained in a 12-in. aluminum cylinder, 36 in. long; it weighs only 65 lb., yet may be operated at any level from 50,000 to 260,000 volts. A trailer unit carries the tube in its own receptacle, motor-generator set, voltage regulator, and pumps and refrigerating system, reels for electrical cables and coolant hose. This set can operate in any place reached by 60-cycle power; another trailer unit carrying a gasoline-driven generator makes the equipment independent, even, of an outside power source.

Mitchell Radiation Products Corp. and General Electric X-Ray Dept. both have similar portable housings for tubes, weighing from 125 to 185 lb. and operating up to 260,000 volts. These have a 360° sweep (as well as limited cone of radiation) and hence may make a search of a complete circumference when placed in a pipe or pressure vessel. Another Mitchell light-weight unit is adaptable for small aluminum spot welds or components of light metals. At this booth can also be seen a high-intensity viewer with a movable light beam enabling the technician to locate a small flaw in a very dense radiograph.

Low cost is not the only attractive feature of the million-volt X-ray machine to be shown by High Voltage Engineering Corp. Constant-potential Van de Graaff generators, tubes with built-in titanium "getters" (eliminating auxiliary vacuum systems), 0.030-in. focal spot – all contribute to speed, definition and penetration.

"Dynamax 150-W" tube with rotating anode (Machlett Laboratories, Inc.) has a 0.3-mm. focal spot, water cooled for high-energy rating, thus being especially adaptable to fluoroscopic inspec-

tion of weldments or castings of aluminum, magnesium and titanium. Machlett representatives believe that its delineation is twice as good as with equipment previously available — equivalent now to 70-mesh screen instead of 30-mesh.

Gamma rays are used for gages or control of operations which cannot be in physical contact with other sensing elements for some reason or other. Nuclear Research Corp. will exhibit such gages for measuring thickness of moving strip, density of liquids or melts, or liquid levels in furnaces or tanks. General-purpose sets include three major items: *(a)* a radioactive source in a protective sphere with collimating aperture, *(b)* a scintillation counter picking up the gamma rays to be measured, and *(c)* an interpretation system. A built-in calibrator is attached to the panel board and presentation system, as well as a continuous radiation monitor to give an alarm should health conditions become hazardous.

Electrical impulses are not the only things used in nondestructive testing. As Don McCutcheon pointed out in his article on p. 141 of last month's *Metal Progress*, high-frequency compression waves (ultrasonics) are used to a greater and greater extent to detect internal defects in raw materials, thickness of metal plates, or continuity of bonding in laminated materials. Equipment manufacturers have done much to improve the indicating devices and their application to unusual situations. For example, Branson Instruments, Inc. will show the new "Sonoray" for verifying internal soundness of parts of uniform cross section. A tank of fluid contains an input transducer at one end and output transducer at the other. Parts to be tested are passed through the tank one by one. Defects (which pass less than normal amounts of energy) are spotted by a transmission tester, which in turn may be connected to signal lights or an automatic ejector.

Nowhere is the dictum that control devices must be rapid and close to the manufacturing operation better illustrated than in Baird Associates' "Spectromet", a direct-reading machine for analyzing metals which can be placed right in the melt shop or foundry. The price is in the $20,000 range, but the manufacturers believe that if only a couple of minutes can be saved on final analysis of each heat, the investment would earn its keep in a busy shop. Another saving would be the cost of an air-conditioned laboratory — the "Spectromet" is airtight and completely sealed.

An even closer approach to nondestructive testing is achieved in newly devised equipment such as the "Norelco Three-Specimen Spectrograph" to be exhibited by North American Philips Co., Inc. and the "ARL X-Ray Scanning Spectrometer" in Applied Research Laboratories' booth. Both of these must be seen in operation to be believed. Our illustration shows the first-mentioned with dismounted specimen holder and box-like goniometer on the table top. The specimen can be rotated at will by the top knob (or continuously by a motor drive). Other arrangements can be made for protective atmospheres or for heating the specimen while under observation. The "ARL" X-ray fluorescence spectrometer is also completely nondestructive, and can analyze materials in liquid, powder or solid form — except for the light elements — and, according to Applied Research Laboratories, rivals slow chemical analyses in accuracy and direct-reading spectrometers in speed.



Branson Instruments' Ultrasonic "Vidigage" for Measuring Thickness and Detecting Laminar Discontinuities

Finally, work-a-day testing equipment should not be overlooked, for exhibitors have new ideas and improved devices to show the visitor. In the field of fatigue testing, the Ivy Co. will show machines ranging in capacity from 200 to 120,000 lb., incorporating, if desired, an automatic program controller which imposes predetermined loads at a predetermined number of cycles. This same booth will have on display a new extensometer for measuring stretch of the entire specimen in a creep test, of such design that it eliminates some of the errors inherent in other automatic creep-measuring devices.

Hardness testing in production line is a tedious

operation at best, so Steel City Testing Machines, Inc., has devised a "Color-Glance" Brinell machine – completely automatic, registering soft, acceptable and hard parts by three colored lights.

In the field of tension testing, Instron Engineering Corp. has a popular table model for small specimens to supplement its large machine covering the range from extremely small loads (2 g.) to fairly large (5 tons). Sieburg Industries has a new portable tool for making standard test pieces from sheet metals, quickly (3 min. max.), and with excellent edges. Finally, Baldwin-Lima-Hamilton Corp., to demonstrate the versatility of its 5000-lb. universal testing machine, will show how easily a new tear test can be made on sheet metals. The sample is 1 in. square, slit halfway down, the notch ending in a 1/32-in. radius. One wing or side is pulled up, the other down, and loads are autographically recorded. Maximum load is reached when the sheet begins to tear. A brittle sheet lets go almost immediately; in ductile sheets the load drops more gradually.

Classified List of Exhibitors and Booth Numbers

Strength-Testing Equipment

Baldwin-Lima-Hamilton Corp.—1954
Buehler Limited—416
Hacker & Co., Inc., William J.—1855
Instron Engineering Corp.—1415
Krouse Testing Machine, Inc.—1880
Olsen Testing Machine Co., Tinius—1428
Riehle Testing Machines Div., American Machine & Metals, Inc.—149
Sieburg Industries—1876
Steel City Testing Machines, Inc.—324

Hardness Testers

Baldwin-Lima-Hamilton Corp.—1954
Bausch & Lomb Optical Co.—440
Buehler Limited—416
Detroit Testing Machine Co.—545
Ercona Corp., Scientific Instrument Div.—2036
Gries Industries, Inc.—240
Hacker & Co., Inc., William J.—1855
Harshaw Scientific Div., Harshaw Chemical Co.—139
Ivy Co.—1949
King, Andrew—349
Olsen Testing Machine Co., Tinius—1428
Riehle Testing Machines Div., American Machine & Metals, Inc.—149
Service Diamond Tool Co.—2135
Steel City Testing Machines, Inc.—324
Torsion Balance Co.—1055
Wilson Mechanical Instrument Div., American Chain and Cable Co., Inc.—1044

Microscopes and Attachments

American Optical Co.—925
Bausch & Lomb Optical Co.—440
Buehler Limited—416
Ercona Corp., Scientific Instrument Div.—2036
Hacker & Co., Inc., William J.—1855
Harshaw Scientific Div., Harshaw Chemical Co.—139
King, Andrew—349
Leitz, Inc., E.—1071
Metal Improvement Co.—2239
North American Philips Co., Inc.—1154
Steel City Testing Machines, Inc.—324
United Scientific Co.—2040

Analytical Equipment and Supplies

American Electro Metal Corp.—1843
Applied Research Laboratories—1219
Baird Associates, Inc.—852
Consolidated Vacuum Corp.—836
Harshaw Scientific Div., Harshaw Chemical Co.—139
Jarrell-Ash Co.—344
Laboratory Equipment Corp.—2159
Lepel High Frequency Laboratories, Inc.—1256
National Spectrographic Labs., Inc.—540
North American Philips Co.—1154
South Florida Test Service—2215
Torsion Balance Co.—1055

Nondestructive Testing

American Cystoscope Makers, Inc.—1678
American Optical Co.—925
Applied Research Laboratories—1219
Atomic Energy of Canada, Ltd., Commercial Products Div.—1929
Baldwin-Lima-Hamilton Corp.—1954
Balteau Electric Corp.—115
Branson Instruments, Inc.—831
Brush Electronics Co.—1728
Curtiss-Wright Corp.—246
Electro Circuits, Inc.—2210
Ercona Corp., Scientific Instrument Div.—2036
General Electric X-Ray Dept.—1572
Hacker & Co., Inc., William J.—1855
Harshaw Scientific Div., Harshaw Chemical Co.—139
High Voltage Engineering Corp.—625
Holger Andreasen, Inc.—961
Machlett Laboratories, Inc.—2049
Magnaflux Corp.—446
Magnetic Analysis Corp.—2024
Mitchell Radiation Products Corp.—2016
North American Philips Co.—1154
Nuclear Research Corp.—1857
Sperry Products, Inc.—1320
Steel City Testing Machines, Inc.—324
Technical Operations, Inc.—2023
Triplett & Barton, Inc.—254
Turco Products, Inc.—1319
Wilson Mechanical Instrument Div., American Chain & Cable Co.—1044

Gages, Comparators and Associated Devices

Applied Research Laboratories—1219
Baldwin-Lima-Hamilton Corp.—1954
Branson Instruments, Inc.—831
Brush Electronics Co.—1728
Consolidated Vacuum Corp.—836
Electro Arc Sales Co.—2242
Ercona Corp., Scientific Instrument Div.—2036
Industrial Tectonics, Inc.—835
Krouse Testing Machine, Inc.—1880
Lufkin Rule Co.—805
Magnetic Analysis Corp.—2024
Metal Improvement Co.—2239
Sperry Products, Inc.—1320
Starrett Co., L. S.—1720
Tubular Micrometer Co.—959

Electronic Test Accessories

Brush Electronics Co.—1728
Peerless Electric Co.—1155
Weston Electrical Instrument Corp.—2224

Scientific Equipment

American Cystoscope Makers, Inc.—1678
Applied Research Laboratories—1219
Bausch & Lomb Optical Co.—440
Cincinnati Sub-Zero Products—970
Curtiss-Wright Corp.—246
Ercona Corp., Scientific Instrument Div.—2036
Hacker & Co., Inc., William J.—1855
Harshaw Scientific Div., Harshaw Chemical Co.—139
Illinois Testing Laboratories, Inc.—919
Ivy Co.—1949
Jarrell-Ash Co.—344
Laboratory Equipment Corp.—2159
Lindberg Engineering Co.—230
North American Philips Co., Inc.—1154
Nuclear Research Corp.—1857
Riehle Testing Machines Div., American Machine and Metals, Inc.—149
South Florida Test Service—2215
Steel City Testing Machines, Inc.—324
Weston Electrical Instrument Corp.—2224

Industrial Equipment and Supplies

In this field a word often heard in discussions is "automation". It was coined 15 years ago as a combination of "automatic" and "motion". Any mechanical transfer of a part from one process to another without human control was soon called automation. Turret lathes and continuous strip mills were cited as examples. When "imagination" was added to its meaning it became a method of thinking about production which has resulted in more general advances. This newer thinking has included even such labor-saving devices as plant safety programs and employment policies intended to reduce labor turnover.

When visitors are shown an "automated" factory what they see is the line of machines all working together. They do not see the specially trained men who make it possible to run machines this way without dissatisfied workers, slowdowns and strikes. Complete automation, where all of the factors of production are analyzed and their influence on cost determined, is still confined to very large plants in high production. Of more general use is semi-automation or partly mechanized manufacture for the producers of smaller quantities, as discussed in *Metal Progress* for March 1954. It contains many thoughts for those who must keep up in the race to get the most from each man-hour of labor, yet with a small budget for new equipment.

Regardless of the type of product, each item that makes a steady flow of work easier to accomplish, each gadget that reduces the dwell between operations, or each contribution that reduces the amount of labor in any operation advances you toward your goal of the best and cheapest product.

As you view the exhibits you will notice a great number of items, often with small changes to make operations simpler and more continuous. These are the bricks and mortar of automation.

Handling of iron parts can be done simply and effectively with magnets. Powerful permanent magnets now available are being used in many ways by Eriez Mfg. Co., exhibiting a new and versatile line of permanent magnetic tools to convey, hold or control material in process. Many shapes and sizes of grooved and flat pulleys are used for guiding and separating. Holders, either bench type, or for conveyer mounting, are used to space, position and clamp workpieces. A "sheet fanner," which magnetizes the edges of steel sheets so that they separate, is combined with rolls to feed sheets quickly and consistently. Other devices are cleaners for liquids and powders, dip-tank retrievers and "Ferrotraps" for removing unwanted iron from anything that flows through pipes. Benefits such as elimination of wires, shorter conveyer lines, faster pick-up, and positive hold-down action, come from the use of powerful "Alnico V" magnets.

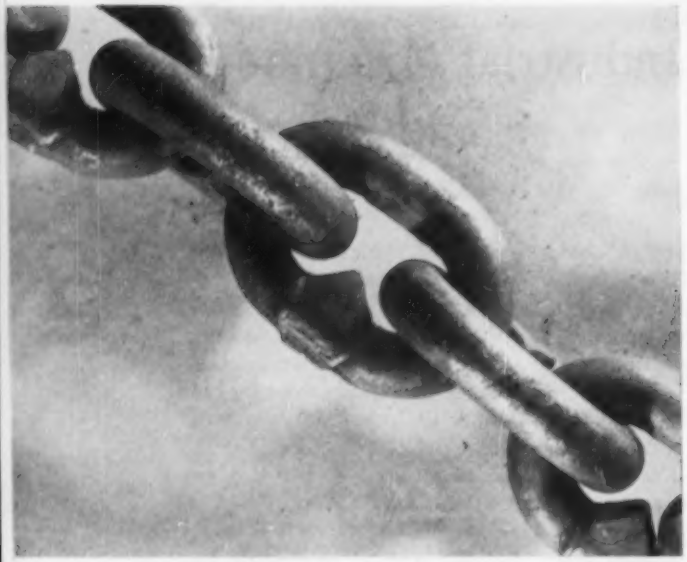
A company that develops complete systems to its customers' requirements, Mathews Conveyer Co., may not have much to show in new standard models, but it can point with pride to special jobs well done. For a brass fabricating plant it has made a complete system for handling slabs, bars and coils, with devices such as tail pullers, bar turnovers, and coil storage spirals.

Coles Cranes, Inc. will show a 7½-ton crane, one of a line of very compact and versatile cranes for loads of 4 to 12 tons. The all-electric power system makes it remarkably reliable.

In the "X-weld" chain American Chain & Cable Co., Inc. uses an insert that prevents kinking. This also increases the weld area to strengthen the resistance welded joints.

Here is an example of one of these simple devices that aids continuous production: "Varitrol" control of "U.S. Varidrive" motors, the main feature of the U. S. Electrical Motors Inc. display. The control can accept its signal in the form of a mechanical push, an electric current or a pneumatic impulse, and use it to set the speed of the drive for any process.

A different variable speed device will be shown by Industrial Research Laboratory, Inc. This one, called "Varislo," is outstanding because it will deliver speed from zero to one-fourth of the input speed. Zero speed position is important in a transmission installed in an automatic system; it eliminates an electrical stop switch with



Resistance "X-Weld" Chain. The lugs help prevent bending and kinking. (American Chain & Cable Co., Inc.)

attendant relays, interlocks and complicated wiring. Another feature is that "Varislo" does not slip. A speed ratio that remains constant is valuable when combining mechanical motions.

Cincinnati Sub-Zero Products is displaying its line of industrial chilling equipment. These units will cool work to − 150° F. Assemblies that require a temperature difference can often be made more easily by lowering the temperature of one than heating the other. For example, if a 300° F. temperature difference is needed, it may be much safer to work from − 100 to 200° F. than from 100 to 400° F. Shrink fits are more easily made if one part is cooled.

The Metal Improvement Co. of Los Angeles has opened a shop in New Jersey specializing in shot-peening for improving metal surfaces, and also forming flat surfaces into dished ones. Forming of aluminum alloy plate up to ½ in. thick can be done. So far only large radius curves have been made by this method.

A much-needed small device is the "Lub-air-ator" shown by A. Schrader's Son Div. of Scovill Mfg. Co., Inc. All too many failures of air tools and air-operated controls can be traced to foreign particles in the air. This little device filters the air, puts the right amount of lubricant in it and controls the pressure. It also permits visual observation of air cleaning and oiling.

A line of fire-resistant hydraulic fluids offered by Socony-Vacuum Oil Co., Inc., will cheer many fire-hazard-conscious executives who would like to use hydraulic operators and controls for furnaces, and other equipment that must be placed close to a flame.

If identification marking gives you any problem be sure to look at the "Flo-master" felt-tip pen of Cushman & Denison Mfg. Co. in 15 different colored inks, all waterproof.

Of great help in explaining new high-speed production lines to top executives are the architectural models being shown by Knight Models, Inc. for plant layouts.

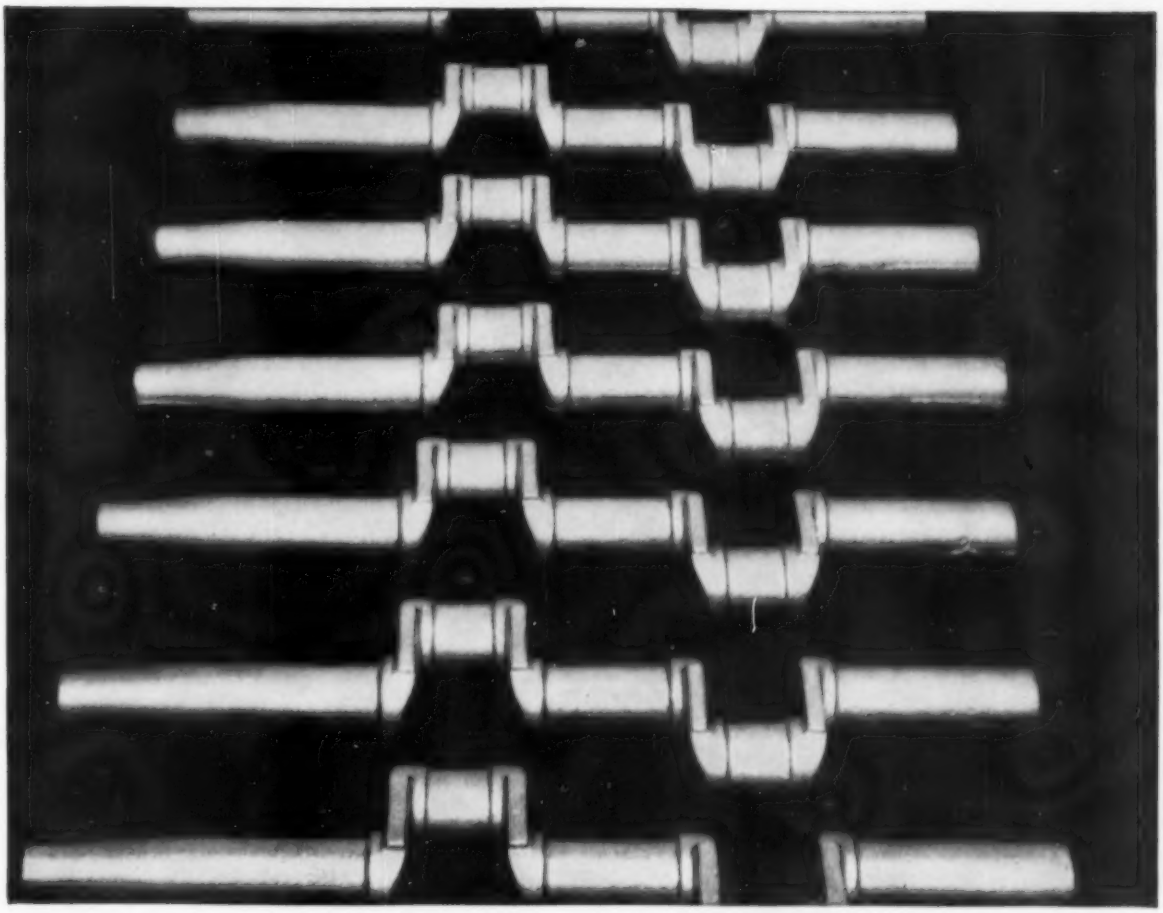
Classified List of Exhibitors and Booth Numbers

Miscellaneous Mill Supplies and Equipment

American Chain & Cable Co.—1044
American Cyanamid Co.—530
American Positive Grip Vise Corp.—2047
Audubon Wire Cloth Corp.—1850
Bradley Washfountain Co.—1861
Chain-Lock Process Co.—2169
Cincinnati Sub-Zero Products—970
Crane Packing Co.—1567
Cushman & Denison Mfg. Co.—2246
Dings Magnetic Separator Co.—2132
Disston & Sons, Inc., Henry—1753
East Shore Machine Products Co.—1756
Electro Dynamic Div., Electro Dynamics Corp.—951
Fawick Airflex Div., Fawick Airflex Corp.—507
Industrial Products Suppliers—958
Industrial Research Lab., Inc.—2053
Jomac, Inc.—1070
Kencliff Corp.—2062
Kinney Mfg. Div., New York Air Brake Company—1171
Knight Models, Inc.—1860
Lake Chemical Co.—506
Marsh Stencil Machine Co.—2147
Metal Improvement Co.—2239
Minnesota Mining and Mfg. Co.—1668
Modernair Corp.—959
Naresco Equipment Corp.—1577
New Hermes Engraving Machine Corp.—1273
Pangborn Corp.—1032
Pantex Mfg. Corp.—2015
Pendergast Safety Equipment Co., Albert W.—2054
Reeves Pulley Co.—445
Schrader's Son Div., A.—1458
Scott Paper Co.—915
Socony Mobil Oil Co., Inc.—1350
Spencer Turbine Co.—1946
Thor Power Tool Co.—731
Torit Mfg. Co.—1454
U.S. Electrical Motors, Inc.—1816
Weatherhead Co.—717

Materials Handling

Acme Steel Co.—1965
Allis-Chalmers Mfg. Co., Buda Div.—1558
Ashworth Bros., Inc.—1461
Audubon Wire Cloth Corp.—1850
Brainard Steel Div., Sharon Steel Corp.—1719
Coles Cranes, Inc.—1387
Day Engineering Co., Inc.—1671
Eriez Mfg. Co.—1917
Harnischfeger Corp.—1657
Industrial Heating Equipment Co.—631
Lapeer Mfg. Co.—706
Minnesota Mining and Mfg. Co.—1668
Merill Brothers—1354
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Standard Stainless Steels, Wrought and Cast

Wrought Stainless Steels *(a)*
(American Iron and Steel Institute Designations; April 1955)

Type	Carbon	Cr	Ni	Other Elements *(b)*	S.A.E. *(c)*
301	0.15 max.	16.0-18.0	6.0- 8.0		30301
302	0.15 max.	17.0-19.0	8.0-10.0		30302
302B	0.15 max.	17.0-19.0	8.0-10.0	Si 2.00-3.00	
303	0.15 max.	17.0-19.0	8.0-10.0	S 0.15 min., P 0.20 max. Mo or Zr 0.60 max.	30303F
303Se	0.15 max.	17.0-19.0	8.0-10.0	Se 0.15 min., P 0.20 max., S 0.06 max.	
304	0.08 max.	18.0-20.0	8.0-12.0		30304
304L	0.03 max.	18.0-20.0	8.0-12.0		
305	0.12 max.	17.0-19.0	10.0-13.0		30305
308	0.08 max.	19.0-21.0	10.0-12.0		
309	0.20 max.	22.0-24.0	12.0-15.0		30309
309S	0.08 max.	22.0-24.0	12.0-15.0		
310	0.25 max.	24.0-26.0	19.0-22.0	Si 1.50 max.	30310
310S	0.08 max.	24.0-26.0	19.0-22.0	Si 1.50 max.	
314	0.25 max.	23.0-26.0	19.0-22.0	Si 1.50-3.00	
316	0.08 max.	16.0-18.0	10.0-14.0	Mo 2.00-3.00	30316
316L	0.03 max.	16.0-18.0	10.0-14.0	Mo 2.00-3.00	
317	0.08 max.	18.0-20.0	11.0-15.0	Mo 3.00-4.00	30317
321	0.08 max.	17.0-19.0	9.0-12.0	Ti is 5 × C (min.)	30321
322★	0.12 max.	16.0-18.0	6.0- 8.0	Ti 1.00; Al 1.00	
325‡	0.25 max.	7.0-10.0	19.0-23.0	Cu 1.00-1.50	30325
347	0.08 max.	17.0-19.0	9.0-13.0	Cb-Ta is 10 × C (min.)	30347
348	0.08 max.	17.0-19.0	9.0-13.0	Cb-Ta is 10 × C (min.), Ta 0.10 max.	
403†	0.15 max.	11.5-13.0		Si 0.50 max.	
405	0.08 max.	11.5-14.5		Al 0.10-0.30	
410	0.15 max.	11.5-13.5			51410
414	0.15 max.	11.5-13.5	1.25-2.50		51414
416	0.15 max.	12.0-14.0		S 0.15 min., P 0.06 max. Mo or Zr 0.60 max.	51416F
416Se	0.15 max.	12.0-14.0		Se 0.15 min., P and S 0.06 max.	
418‡	0.15 max.	12.0-14.0			
420	Over 0.15	12.0-14.0			51420
420F‡	0.30-0.40	12.0-14.0		Same as Type 303	51420F
430	0.12 max.	14.0-18.0			51430
430F	0.12 max.	14.0-18.0		Same as Type 416	51430F
430FSe	0.12 max.	14.0-18.0		Same as 416 Se	
431	0.20 max.	15.0-17.0	1.25-2.50		51431
440A	0.60-0.75	16.0-18.0		Mo 0.75 max.	51440A
440B	0.75-0.95	16.0-18.0		Mo 0.75 max.	51440B
440C	0.95-1.20	16.0-18.0		Mo 0.75 max.	51440C
440F‡	0.95-1.20	16.0-18.0		*(d)*	51440F
442‡	0.20 max.	18.0-23.0			51442
443‡	0.20 max.	18.0-23.0	0.50 max.	Cu 0.90-1.25, Si 0.75 max.	
446	0.20 max.	23.0-27.0		N_2 0.25 max.	51446
501	Over 0.10	4.0- 6.0		Mo 0.40-0.65	51501
502	0.10 max.	4.0- 6.0		Mo 0.40-0.65	

Cast Stainless Steels *(e)*
(Alloy Casting Institute Designations; 1954)

Type *(f)*	Carbon	Si (Max.)	Cr	Ni	Others *(g)*
CA-15	0.15 max.	1.50	11.5-14.0	1.0 max.	*(i)*
CA-40	0.20-0.40	1.50	11.5-14.0	1.0 max.	*(i)*
CB-30	0.30 max.	1.00	18.0-22.0	2.0 max.	
CC-50	0.50 max.	1.00	26.0-30.0	4.0 max.	
CE-30	0.30 max.	2.00	26.0-30.0	8.0-11.0	
CF-8	0.08 max.	2.00	18.0-21.0	8.0-11.0	
CF-8C	0.08 max.	2.00	18.0-21.0	9.0-12.0	Cb or Cb + Ta *(h)*
CF-8M	0.08 max.	1.50	18.0-21.0	9.0-12.0	Mo 2.0-3.0
CF-12M	0.12 max.	1.50	18.0-21.0	9.0-12.0	Mo 2.0-3.0
CF-16F	0.16 max.	2.00	18.0-21.0	9.0-12.0	Mo 1.5 max. P 0.17 max. Se 0.20-0.35
CF-16Fa¶	0.16 max.	2.00	18.0-21.0	9.0-12.0	Mo 0.40-0.80 S 0.20-0.40
CF-20	0.20 max.	2.00	18.0-21.0	8.0-11.0	
CH-20	0.20 max.	2.00	22.0-26.0	12.0-15.0	
CK-20	0.20 max.	2.00	23.0-27.0	19.0-22.0	
CN-7M	0.07 max.	*(j)*	18.0-22.0	21.0-31.0	Mo; Cu *(j)*
HA	0.20 max.	1.00	8.0-10.0		Mo 0.90-1.20
HC	0.50 max.	2.00	26.0-30.0	4.0 max.	*(i)*
HD	0.50 max.	2.00	26.0-30.0	4.0- 7.0	*(i)*
HE	0.20-0.50	2.00	26.0-30.0	8.0-11.0	*(i)*
HF	0.20-0.40	2.00	19.0-23.0	9.0-12.0	*(i)*
HH	0.20-0.50	2.00	24.0-28.0	11.0-14.0	N 0.2 max. *(i)*
HI	0.20-0.50	2.00	26.0-30.0	14.0-18.0	*(i)*
HK	0.20-0.60	3.00	24.0-28.0	18.0-22.0	*(i)*
HL	0.20-0.60	3.00	28.0-32.0	18.0-22.0	*(i)*
HN	0.20-0.50	2.00	19.0-23.0	23.0-27.0	*(i)*
HT	0.35-0.75	2.50	13.0-17.0	33.0-37.0	*(i)*
HU	0.35-0.75	2.50	17.0-21.0	37.0-41.0	*(i)*
HW	0.35-0.75	2.50	10.0-14.0	58.0-62.0	*(i)*
HX	0.35-0.75	2.50	15.0-19.0	64.0-68.0	*(i)*

★Not an A.I.S.I. standard; also known as "stainless W".
†Turbine quality. ‡Not an A.I.S.I. standard.
¶Not an A.C.I. standard.

Notes on Wrought Steels

(a) All composition ranges are based on ladle analysis. Standard permissible variations from specified chemical ranges or limits for check analysis are shown in Section 24, Steel Products Manual.

(b) **Manganese:** 2.00 max. in all 300 types except S.A.E. 30325 which has 0.60 to 0.90, and S.A.E. 30347 which has 2.50 max.; 1.00 max. in all 400 and 500 types except 416, 416Se, 430F, 430FSe (1.25 max.) and 446 (1.50 max.). Manganese in S.A.E. 51420F and 51440F is 1.25 max. **Silicon:** 1.00 max. in all types except 302B (2.00 to 3.00), 310 and 310S (1.50 max.), 314 (1.5 to 3.0), and 403 (0.50 max.). Silicon in S.A.E. 30321 and 30347 is 1.50 max. and in 30325 is 1.00 to 2.00. **Phosphorus** is 0.045 max. in all the 300 series except 303 and 303Se, and 0.040 max. in all other types except 416, 416Se, 430F, and 430FSe. **Sulphur** is 0.030 max. in all types except 303, 303Se, 416, 416Se, 430F, and 430FSe.

(c) S.A.E. composition limits as of January 1952 may be slightly different from the A.I.S.I. analyses quoted.

(d) Same as in 51416F (416) except that Mn or Zr is 0.75 max.

Notes on Cast Steels

(e) Most of these are also covered by A.S.T.M. specifications A217-49T, A296-49T and A297-49T.

(f) Designations with the initial letter C indicate alloys generally used to resist corrosive attack at temperatures less than 1200° F. Designations with the initial letter H indicate alloys generally used under conditions where the metal temperature is in excess of 1200° F.

(g) **Manganese:** 1.00 max. in CA-15, CA-40, CB-30 and CC-50; 1.50 max. in all other C alloys; 0.35 to 0.65 in HA; 1.00 max. in HC; 1.50 max. in HD; 2.00 max. in all other H alloys. **Phosphorus** and **sulphur:** each 0.04 max. in all alloys except CF-16F, wherein P is 0.17 max., and in CF-16Fa, wherein S is 0.20 to 0.40.

(h) Columbium 8 × C min., 1.00% max.; Cb + Ta 10 × C min., 1.35 max.

(i) Molybdenum 0.5 max. (not intentionally added).

(j) Proprietary alloys contain varying amounts of Si, Mo and Cu.



Sealed Power Corp. operates baths trouble-free for over 5 years with

AEROHEAT® 1000 and 300

heat treating compounds

Sealed Power Corp., Muskegon, Michigan, is a leading manufacturer of pistons, rings and cylinder sleeves for original equipment and service replacement in heavy-duty internal combustion engines. Heat treating helps give these parts the ruggedness they need to stand up in high-speed, high-compression engines.

Gray-iron cylinder sleeves are hardened in self-rectifying AEROHEAT 1000 up to 500 Brinnell to meet customer service conditions. Tempering is done in a nitrate/nitrite bath of AEROHEAT 300. Regular additions to each bath have kept both operating trouble-free for more than five years, with excellent electrode life. This is two years longer than normal life expectancy of high-temperature ceramic pots—a tidy bit of maintenance cost-saving.

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Cylinder sleeves (wet type, left; and dry type, right) get extra hardness with minimum distortion in non-decarburizing AEROHEAT 1000 bath. High purity AEROHEAT 300 is used for tempering.

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AEROHEAT® Heat Treating Compounds
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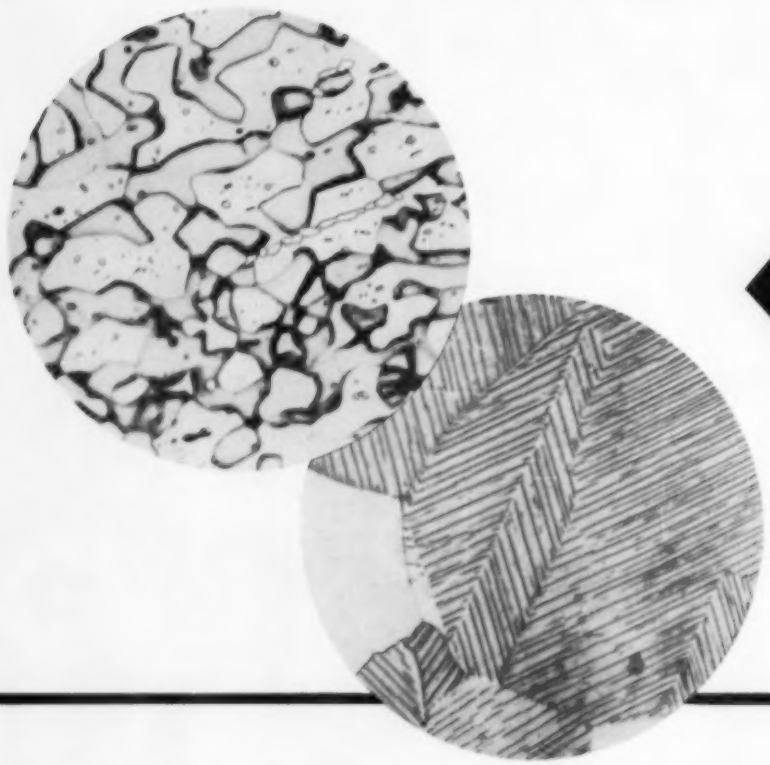
Bausch & Lomb Salutes:

Mary E. Potter

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WINNER OF BLUE RIBBON AWARDS for best photomicrographs in the *Stainless Steels and Heat Resisting Alloys* Class and in the *Carbon and Alloy Steels* Class—Miss Mary E. Potter, U. S. Steel Corporation, South Works, Chicago, Illinois.

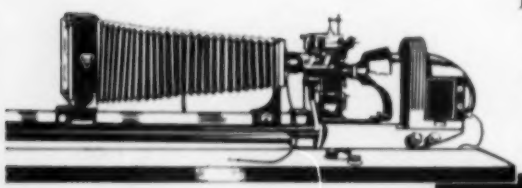


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SINCE 1853

One Hundred Years of Metallurgy at Yale

The first American professorship in metallurgy was established just a century ago during the formative stages of Sheffield Scientific School. George J. Brush was the first incumbent. Fifty years ago the Hammond Metallurgical Laboratory was built, and 48 years ago Champion Herbert Mathewson joined the faculty. (A 2, A 3)

THE HISTORY of American metallurgy as a defined subject of instruction began in 1855 with the establishment by the Yale Corporation of "a new professorship in the Department of Philosophy and the Arts to be known as the Professor of Metallurgy"—stipulating, however, that none of the funds belonging to the Academical Department be used in support of this professorship! The first incumbent of the new chair was George J. Brush who had graduated in 1852 after taking virtually all of the courses in chemistry and mineralogy then offered at Yale. After his appointment Brush studied in England and Germany and returned to New Haven in 1857 with the reputation of being the best qualified man in the English speaking world to teach metallurgy, with the important exception of Dr. John Percy of the Royal School of Mines, London, under whom he had studied during his sojourn abroad.

Unfortunately Professor Brush had little opportunity to teach metallurgy after assuming his new position. According to Chittenden's History of the Sheffield Scientific School, Brush gave public lectures on the metallurgy of iron and steel in New Haven, but there are no records indicating that he conducted any classes in this subject. Metallurgy was not required in the curriculum of either chemistry or civil engineering wherein all of the students in the department of philosophy and arts were enrolled.

However, mineralogy was required in both courses and consequently Brush's original interest in this subject was revived and greatly intensified. In 1871 his title was changed to professor of mineralogy. Today the only tangible evidence of Brush's early interest in metallurgy may be found in a collection of specimens typifying European smelting practices in the middle of the last cen-



C. H. Mathewson

Instructor in Metallography, 1907
Assistant Professor of Metallurgy, 1911
Professor of Metallurgy and Metallography, 1919-50

tury, collected by him during his visits abroad. After reposing for half a century in the basement of Sheffield Hall they were examined and catalogued by Professor Mathewson and now may be found in the Hammond Metallurgical Laboratory's museum.

In recognition of the collateral importance of mining and metallurgy, and in spite of the situation created by Professor Brush's defection from metallurgy to mineralogy, the Yale Corporation established in 1865 a professorship of mining, again with the proviso that the incumbent be appointed "without salary from existing funds". Professor Alfred P. Rockwell, Yale '35, also known as Colonel Rockwell, formulated a well-balanced curriculum in mining and metallurgy which appeared in the 1866 catalogue. However, soon after this auspicious start Rockwell left Yale for the newly established Massachusetts Institute of Technology. The reason was contained in the Annual Report of Sheffield Scientific School: "We have been compelled to part with the services of one of our associates for the simple reason that a kindred institution in another city could offer him a suitable salary for his services, which our resources did not permit us to pay."

After Rockwell's departure interest in mining education at Yale lapsed for 40 years. However the metallurgical seedling planted by Rockwell in 1866 bore some fruit, for we find in the program of the graduating class of July 1869 that Nelson Powell Hulst, of Alexandria, Va., was awarded a prize of $20 for his proficiency in metallurgy.

Quite understandably metallurgy now developed as analytical chemistry. Oscar D. Allen, in 1871, was appointed professor of metallurgy and assaying, a title changed two years later to professor of analytical chemistry and metallurgy. He did outstanding work on analytical procedures for the rare metals and, until his retirement in 1887, his interests were mainly concerned with analytical processes adapted to minerals and metallic materials.

This trend toward analytical chemistry as a dominant interest, with metallurgy in a minor role, was continued under the leadership of Horace L. Wells, one of Professor Allen's students. In 1893 he was appointed professor of analytical chemistry and metallurgy. Drawing on his experience at the Colorado Coal and Iron Co.'s plant at South Pueblo, he taught assaying and the metallurgy of iron and steel to students in chemistry who elected these courses in substitution for the courses in organic chemistry. This modified curriculum was designated "Chemistry Preparatory to Metallurgy".

At the turn of the century the necessity for training men in geology and mining was recognized at Yale. Moreover, it was evident that metallurgical education should no longer continue as an appendage of chemistry. Instruction should be given by a department of mining and metallurgy with adequate laboratory facilities. In his report for 1902, the director of Sheffield Scientific School expressed the hope "that someone will recognize the importance of such a laboratory in the training of young men, and will provide the means by which the plan can be put into effect."

John Hays Hammond, an eminent mining engineer and an 1876 graduate, promptly donated money for the site on Mansfield St. Plans for the laboratory for the teaching of assaying, ore dressing, mining engineering and metallurgy, which was to be the largest of its kind in the country, were prepared by W. Gedney Beatty, an architect, and Louis D. Huntoon, a mining engineer recommended by Mr. Hammond. Ground was broken for the Hammond Metallurgical Laboratory in June 1904, and the building was ready for occupancy in November 1905. Records show the total cost of the land, building and equipment to be $128,741.53.

Mining Engineering – During the formulative period of the undertaking Mr. Hammond served on the Governing Board of the Sheffield Scientific School as titular professor of mining engineering, but relied on Mr. Huntoon to handle the details of the program. Huntoon, a graduate of the Columbia School of Mines, 1895, was appointed assistant professor of mining and metallurgy in 1904. In 1908 he was made professor of mining and metallurgy and gave instruction in assaying and ore dressing until 1911, when he resigned to enter consulting practice.

Meanwhile, James F. McClelland, who had taught mining engineering at Columbia and Stanford, following several years' experience in operating capacities, joined the Sheffield staff as a lecturer. In 1909 he was named professor of mining engineering and head of the department of mining and metallurgy. McClelland assembled a small staff of specialists who trained a fine body of men, many of whom later became prominent mining engineers.

In 1911, Luther W. Bahney was appointed assistant professor of mining and metallurgy. He taught assaying and several courses in extractive metallurgy until 1917 when he went with the Scovill Mfg. Co.

Arthur F. Taggart, Stanford 1909, was appointed instructor in mining in 1911, to share with McClelland the instruction in mining and to develop the courses in ore-dressing. (Taggart was especially competent in this subject and later attained recognition for his outstanding work on modern flotation processes.) After ten years at Yale he was appointed professor of ore dressing at Columbia University.

Metallurgy – For some years after completion of Hammond Laboratory, the main interest in *metallurgy* continued to be in analytical procedures and extractive metallurgy. With the rapid growth of the metal consuming industries it became evident that metallurgy should be directed toward the utilization of metallic materials – a trend in interest already clearly evident in England and Germany.

One of the few men in the United States to foresee the future significance of this type of metallurgy was C. H. Mathewson. After his graduation in chemistry from Sheffield in 1902, he worked two years in Tammann's laboratory at Goettingen, Germany, on phase relations and equilibria in metal systems. However, this change in instructional program in metallurgy is concerned with *two* Yale men. Looking back 50 years we can picture Mathewson busily studying in Germany some fundamental relationships based on the teachings of another Yale man, Josiah Willard Gibbs, who some 30 years before had pointed the way in his famous paper "On the Equilibrium of Heterogeneous Substances".

Mathewson returned to Yale in 1907, as instructor in chemistry and metallography. Together with large freshman classes in chemistry, he taught microscopic metallurgy and constitutional relationships in alloy systems in courses which were gradually introduced into the programs of men preparing for a career in metallurgy or mining. Thus, Yale was one of the first educational institutions in the United States to become prominent in metallography – or, in the more modern terminology, physical metallurgy – a subject that is primarily concerned with the interrelationships between constitution, structure and properties of metallic materials.

In recognition of Mathewson's interest and accomplishments in the field of metallurgy he was made assistant professor of metallurgy in 1911 and joined the staff of the department of mining and metallurgy. Unfortunately, after World War I the strong department assembled by McClelland was reduced in personnel to one man, Dr. Mathewson. In 1919 he was appointed professor of metallurgy and metallography and it was decided to direct metallurgical efforts mainly toward the field of physical metallurgy, retaining,



Arthur Phillips

Assistant Professor of Metallurgy, 1919
Professor of Metallurgy, 1950

however, supplemental courses in extractive metallurgy.

In 1919, Dr. Mathewson induced Arthur Phillips, Yale 1913, to leave the Bridgeport Brass Co. and become assistant professor of metallurgy with teaching assignments in physical metallurgy and metal technology. In 1924, William E. Milligan (University of Toronto 1914) was appointed instructor and took over the metallurgical treatment of ores and assaying. Extractive metallurgy continues to be his principal interest as associate professor of metallurgy.

This is hardly the place to recount the vicissitudes of the work in mining engineering at Sheffield. Suffice it to say that B. B. Gottsberger was appointed professor of mining in 1922. He had been a successful mining operator and consulting engineer. Robert K. Warner assisted him in taking charge of work in ore dressing. This arrangement lasted only four years, when Gottsberger resigned. Henry A. Behre, Yale 1913, was then appointed assistant professor, and he remained until 1931.

Resignations of Gottsberger and Behre led to a decision by Yale Corporation to terminate instruction in mining in 1934, and the department thereupon became the department of metallurgy. In 1938 the small staff was augmented by the appointment as instructor of Robert M. Brick (who resigned in 1945 to become director of the department of metallurgy at the University of Pennsylvania). His successor, Walter R. Hibbard, Jr., a graduate of Sheffield Scientific School, resigned in 1951 to enter the research department of the General Electric Co.

In 1950, after 43 years of continuous service to Yale and 39 years of activity in the department, Dr. Mathewson retired. It is impossible to detail his contributions to metallurgical education and his service to Yale University. Arthur Phillips, the present chairman of the department of metallurgy, could find no adequate words to express the admiration and affection which his students and associates feel toward Dr. Mathewson.*

The faculty of the department of metallurgy now consists of Prof. Arthur Phillips and three associate professors: William E. Milligan, Arthur S. Nowick and William D. Robertson. The latter two members of the staff are relatively new appointees. Robertson came to Sheffield in 1950 by way of the Kingston Research Laboratory of Aluminium Laboratories, Ltd., M. I. T. graduate school, and the Institute for the Study of Metals at the University of Chicago. Nowick also joined the faculty in 1951 from the Institute for the Study of Metals, having previously been research physicist for the National Advisory Committee for Aeronautics.

In Retrospect – During the past century Yale has turned out a large body of men well grounded in the fundamental sciences, supplemented by courses specifically concerned with the mechanical and metallurgical treatment of ores for metal production, and more recently with emphasis placed on the industrial adaptation and utilization of metallic materials. This training has been carried on in the favorable environment of a liberal arts college.

Many of the graduates of Hammond Metallurgical Laboratory may be found in America's industries foremost in metal producing and metal consuming. Some have attained executive or managerial positions, others function as directors of research, and still others have become prominent in production and technology. They have contributed much to the national professional societies, such as the American Society for Metals and the American Institute of Mining and Metallurgical Engineers, either as local and national officers or committee members, and by contributions to the professional transactions and literature. Since 1915, some 80 papers have been published by these two societies alone concerned only with the investigations carried on by graduate students while at Hammond Laboratory! The number subsequently published by these men during their professional careers would multiply this figure many times.

Yale graduates have also become prominent in the field of metallurgical education. At the present time, 13 professors are known to be engaged in teaching or university research at nine American educational institutions.

Almost 30 years ago the graduates of the department organized an informal alumni association, later to be known as the Yale Metallurgical Alumni. This loyal and active group, consisting of more than 600 members, has maintained close contact with the department and has always been responsive to its needs. A celebration this year of the 100th year of metallurgy at Yale and the 50th year of the Hammond Metallurgical Laboratory results from their desire to recognize the past accomplishments of the department and to express the conviction that the past will be only a prologue for the second century of metallurgy at Yale University.

*A biographical appreciation of Champion Herbert Mathewson, investigator, teacher, metallurgist, appeared in *Metal Progress* for February 1942.

Protecting Molybdenum From Oxidation

*By ALVIN J. HERZIG and JAMES R. BLANCHARD**

Cladding, electroplating, metal spraying and ceramic coating offer promise for protecting molybdenum under various conditions and services. (L 17, L 23, L 24, L 27, Mo)

A PRECEDING article of this series indicated that molybdenum and molybdenum-base alloys for use at elevated temperatures are critically deficient in resistance to oxidation. Anyone who has observed the rapid deterioration of a sample of molybdenum oxidizing in air at temperatures above 1450° F. might challenge the application of molybdenum as a refractory metal without further ado. However, to reject the possibility of a practical solution to this deficiency is to deny many opportunities applying its excellent strength characteristics. Although the problem is complex and has not yet been solved on a commercial scale, molybdenum has been protected for useful periods of time at temperatures well above those required in many modern heat engines.

The "nobility" of metals depends upon their ability to generate protective surface films (usually oxides). Molybdenum oxidizes at elevated temperatures and deteriorates rapidly because it has utterly no capacity to provide a protective coating of oxide. Molybdenum trioxide – the product of the oxidation reaction of molybdenum – volatilizes readily above 1450° F. Actually, in an ample supply of oxygen at concentrations no higher than that of the air, oxidation can result in a self-accelerating exothermic process. While in a few high-temperature environments oxidation resistance is not a controlling factor, most projected uses are in gases of relatively high oxygen content and at such velocities and temperatures that unprotected molybdenum would be

*President and Project Engineer, Respectively, Climax Molybdenum Co. of Michigan, Detroit. Previous articles in this series on arc-cast molybdenum, written by N. L. Deuble, were published in the April, May, June, July and August issues of *Metal Progress*.

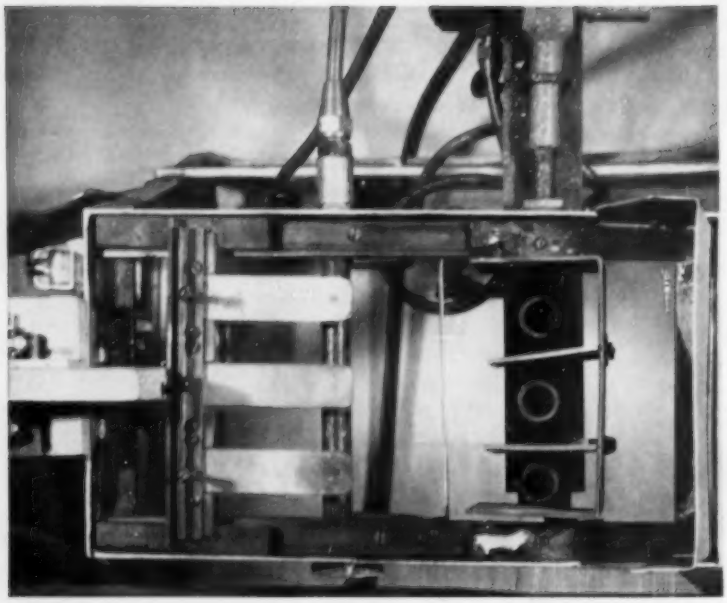


*Fig. 22 – For Thermal Shock Testing Three Samples Are Heated Rapidly to 1800° F. in a Gas Flame, Held 15 Sec., Then Cooled to Room Temperature in an Air Blast**

virtually useless. The outstanding high-temperature strength of molybdenum and its alloys will only be widely applicable when methods of protection have been established.

There are three possible ways to protect molybdenum successfully:

1. Alloy the metal so that it can form a surface composed of stable refractory phases containing molybdenum and oxygen.

2. Prohibit access of oxygen to the metal by inert and impervious coatings.

3. Combine these possibilities in a coating of complex composition.

The first requires incorporation of an alloy which, when oxidized, will form a stable molybdate or other complex compound. The second requires a superficial inert coating impervious to oxygen. The third possibility requires a superficial coating capable of reacting with the underlying metal or perhaps with oxygen to generate a protective coating.

Alloying – Extensive investigation of the potential binary alloy systems of molybdenum has not revealed any element that might form a protective oxide or molybdate. While some alloys can be made which deteriorate 100 times less rapidly than pure molybdenum, they still deteriorate about 20 times faster than the acceptable limit for a so-called oxidation resistant material. Furthermore, these systems contain other elements in such great amounts that the desirable characteristics of molybdenum are no longer present. A study of certain more stable molybdates has indicated that this approach to the problem involves other complications not likely to be resolved at an early date.

Inert and Impervious Coatings – The methods commonly employed for providing protective or decorative surfaces have been investigated to determine their adaptibility to molybdenum. These coatings have been applied by dipping, diffusion, cladding, plating, vapor deposition and spraying. They have varied from highly refractory but brittle ceramics to less refractory but ductile metal-clad and plated surfaces. The results have been promising in spite of the fact that maintenance of an impervious coating on molybdenum is extremely difficult. Perfect coverage must be maintained, or the molybdenum underneath will be completely and rapidly oxidized by the presence of even one small imperfection. The coating must possess some plasticity, be resistant to thermal shock, capable of withstanding mechanical impact, and resistant to erosion. Furthermore, it is highly desirable, if not absolutely essential, that the coating process does not require temperatures which would result in recrystallization of the metal. If recrystallization does occur, the strength and toughness imparted by previous working will be lost.

*Figures and tables are numbered consecutively, from the preceding article in August.

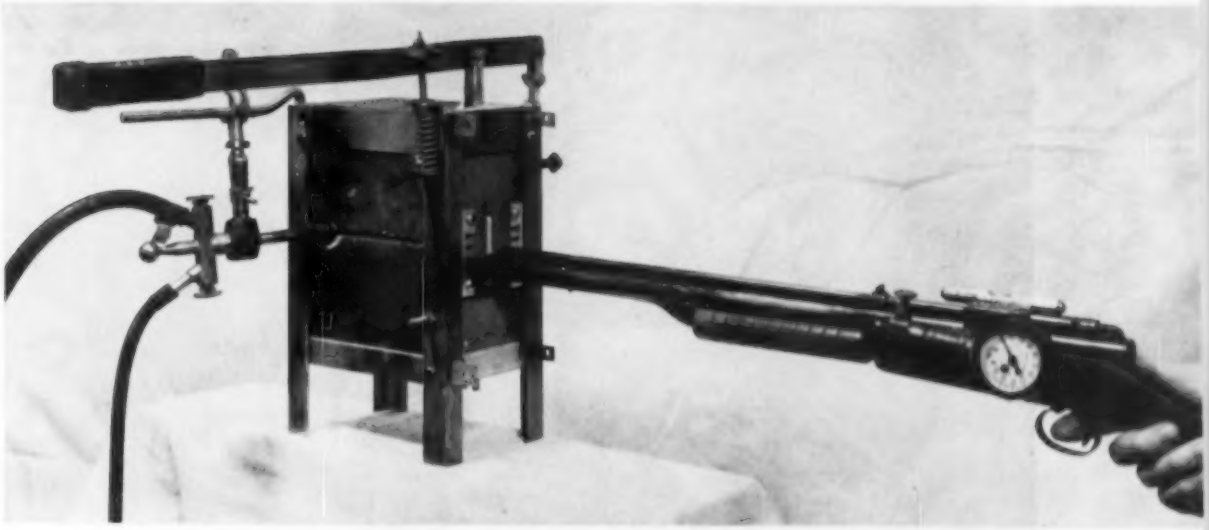


Fig. 23 – In the Ballistic Impact Test the Specimen is Heated in a Small Furnace and Hit With Steel Shot From an Air Rifle

Nevertheless, coatings of this type have been developed to the point where they approach the degree of protection required in certain ordnance applications.

Coatings That Tolerate Oxidation – The vulnerability of inert and impervious coatings to microscopic defects has caused considerable investigation on coatings of complex composition. In general, they are not initially impervious but appear to attain their protective and refractory characteristics through diffusion of molybdenum into them. They also appear to benefit from the internal formation of oxidation products. Because such coatings can be self-healing, they are regarded as more promising.

Evaluation Tests for Coatings

The potential merit of a coating may be forecast to some extent by relatively low-cost laboratory tests. These are the simple oxidation test, the thermal shock test, ductility test, ballistic impact test and erosion test.

The oxidation test consists of holding the specimen at temperature in an oxidizing environment of constant composition until incipient failure is detected. In a practical test, the specimens are actually cooled once a day for inspection purposes. Generally, failure is revealed by the emanation of molybdic oxide but occasionally incipient failure is detectable in the daily inspection. Most testing is done at 1800° F. If the coating remains effective for 500 hr., it is considered worthy of further development and evaluation.

The thermal shock test consists of repeated heating and cooling of a specimen until failure occurs. In the apparatus shown in Fig. 22, three samples are tested simultaneously. They are heated to 1800° F. in 30 sec. by the impinging flame, held at temperature for 15 sec. and then withdrawn from the flame to an air blast in which they are cooled to 80° F. in 45 sec. Coatings which endure 400 cycles are considered worthy of further development and evaluation.

Ballistic Impact Test – In this test (see Fig. 23) the coated specimen is heated in a small furnace to the test temperature. The edge of the specimen is impacted several times with steel shot 0.173 in. in diameter, propelled at a velocity of 330 ft. per sec. by an air rifle. After impacting, the specimen is removed from the furnace and subjected to a static oxidation test in air at a temperature of 1800° F.

Ductility Test – It has been arbitrarily assumed that a useful coating should withstand 2% elongation without loss of capacity to protect molybdenum against oxidation. One of the methods used for ductility testing has been to load the coated specimen in creep-rupture testing equipment so that plastic deformation, amounting to 2 to 5% elongation, is produced during a 100 or 500-hr. period at 1800° F. The coating must re-

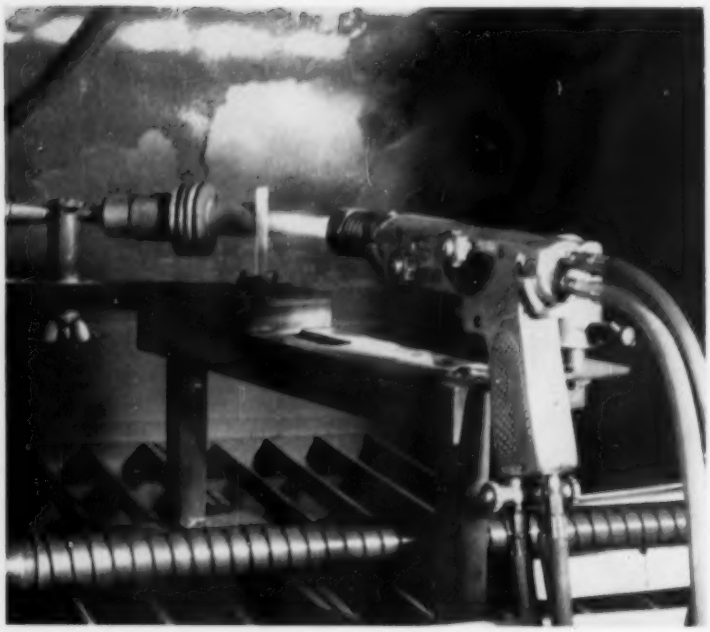


Fig. 24 – Hot Aluminum Oxide Is Blown on Coated Specimen to Evaluate Resistance to Erosion

main effective throughout the test. The second method is to elongate the coated specimen 2 to 5% in the hot tensile test and subsequently subject the specimen to a static oxidation test.

The erosion test consists of heating the coated specimen and subjecting it to a blast of hot abrasive particles impinging on the coated surface at an angle of 45°. The abrasive blast is controlled so that 30 g. per min. of 90-mesh aluminum oxide impinges on the specimen. The erosion test apparatus is shown in Fig. 24.

Evaluation of Sprayed Coatings

The compositions of some typical sprayed metal coatings are shown in Table VII. They are of two general types: *(a)* those high in silicon that are mixed with aluminum for spraying and *(b)* those based on nickel and boron that are sprayed without aluminum. Because of the rapid rate of interdiffusion of aluminum and molybdenum (and possibly other elements), the solidus temperature of the first type is raised sufficiently to enable such coatings to be useful at temperatures to 2400° F. Alloys containing nickel and boron have melting points below 2000° F. Apparently, the elements in the nickel-boron group of alloys interdiffuse slowly with molybdenum at 2000° F. For this reason these coatings have too much molten phase for use above about 1800 to 2000° F.

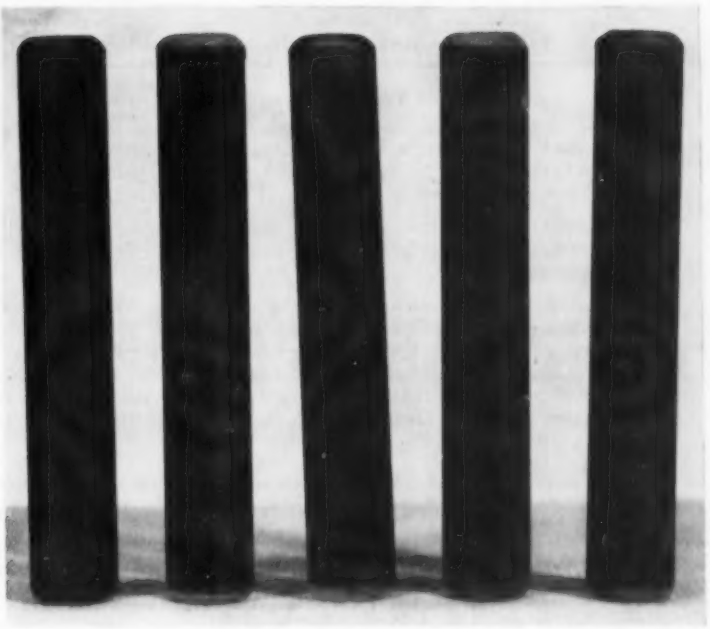
There are three important steps in applying sprayed coatings.

Preparation of the Surface – Sharp corners and edges are rounded slightly with a file to get good coverage of the base metal. All surfaces are roughened by grit-blasting to facilitate mechanical bonding of the coating to the molybdenum. Since grit particles embedded in the molybdenum during blasting constitute a potential failure point, S.A.E. Grade G-25 iron grit is used rather than refractory oxide grit. The iron grit can be removed from the molybdenum surface by treatment with hot concentrated hydrochloric acid.

Spraying – The spray gun is operated mechanically to insure uniform thickness. For flat parts its traverse is in a horizontal direction. Between passes the gun is displaced in a vertical direction and this sequence is continued until the entire surface has been coated. The article is turned 90° in the same plane and another series of passes is made which applies another layer on top of the first. This procedure is repeated until a coating 0.012 to 0.015 in. thick has been built up. The opposite side of the flat article is then similarly coated. Edges are coated last. Cylindrical or circular shapes are rotated continuously.

Diffusion Treatment – The spray-coated article is painted with a slurry consisting of fine aluminum oxide powder and methyl alcohol. This paint prevents adherence of the coating to the

Fig. 25 – Molybdenum Coated With 0.005 in. Al-Cr-Si Alloy After 500 hr. at 1800° F.



supporting rack during subsequent diffusion heat treatment. The article is heated in a purified and dried hydrogen atmosphere for 2 hr. at 2000° F. to consolidate the coating and bond it metallurgically to the molybdenum.

Such coatings are not sufficiently smooth for many applications. Where dimensional tolerances are limited, or where a smooth surface finish is necessary, the coatings can be surface ground to the required specifications. Conventional methods of grinding with silicon carbide wheels are satisfactory.

Tests on Sprayed Coatings

All alloy compositions listed in Table VII protect molybdenum against oxidation in air for at least 500 hr. at 1800° F. Tests with groups of ten specimens showed that the chromium-silicon alloy, the Colmonoy 5 and 6 alloys, and the Coast Metals Modified 50 alloy, provide consistent protection. In tests extending over a long period of time, 75 consecutive specimens coated with the aluminum - chromium - silicon composition sustained 500 hr. exposure without failure.

Five coated bars of molybdenum exposed to air at 1800° F. for 500 hr. are shown in Fig. 25. The Al-Cr-Si coating on these bars was mechanically finished to a thickness of 0.005 in. before exposure. None of the five specimens exhibited failure points after the test.

Only the Al-Cr-Si coating has been tested at 2100 and 2400° F. Oxidation tests at 2100° F. with only ten specimens indicated that protection is afforded for at least 200 hr. and as much

Table VII – Composition of Sprayed Metal Coatings for Molybdenum

Coating Alloy	Si	Cr	Al	Ni	Mo	B	Fe	Other
	Mixed With Aluminum for Spraying							
Cr-Si alloy	40.55	55.96	0.44				1.40	
Cr-Mo-Si	32.97	31.30			31.29		0.71	
Mo-Ni-Si	32.17		1.53	30.57	37.0		0.22	
Fe-Si	50.78						Bal.	
Ni-Si	30			60			7	3 Ca
	Sprayed Without Aluminum							
Colmonoy No. 5	4.01	12.07		79.16		2.36	4.13	0.46 C
Colmonoy No. 6	4.33	15.29		72.19		2.77	4.41	1.02 C
Coast Metals Mod. 50 alloy	3.5			93.25		2.25		1.00 C

Table VIII – Results of Tests on Sprayed-Metal Coatings for Molybdenum

Type of Test	Al-Cr-Si	Colmonoy No. 5	Coast Metals Mod. 50
Thermal shock tests on three specimens; number of cycles to failure	504-424* 578-484 627-560	185-225* 285 185-225	121-112* 108-127 150-112
Ballistic impact test on three specimens; velocity of steel shot 330 ft. per sec.; life of coating at 1800° F. after impacting	0† 0† 0	500+ hr. 500+ 500+	47 hr.‡ 500+ 500+
Erosion test on two specimens, using 30 to 33 g. per min. No. 90 aluminum oxide grit; life of coating at 1800° F.	30-25 min.* 25-25	60-60 min.* 60-57	40-50 min.* 50-50

*The two figures are for each end of the specimen.
†With a velocity of shot of 135 ft. per sec., life of the first two specimens was 160 and 170 hr. respectively.
‡Failure occurred at area of coating damaged by clamping device.

as 500 or more hours. At 2400° F., an initial group of ten specimens failed after exposures of 200 to 350 hr.

Thermal Shock Tests – The results of thermal shock tests on specimens coated with Al-Cr-Si, Colmonoy No. 5, and Coast Metals Modified 50 alloy, are given in Table VIII. In this test, the Al-Cr-Si coating was superior to the other compositions tested.

Ductility Tests – Elongation of specimens coated with the Al-Cr-Si and Colmonoy No. 5 and 6 alloys ranged from 2 to 5% during 100 and 500-hr. periods of stressing at 1800° F. without coating failure.

Ballistic Impact Test – Three specimens coated with the Al-Cr-Si alloy, Colmonoy No. 5 alloy, and Coast Metals Modified 50 alloy, were subjected to four impacts at 1800° F. The life of specimens in subsequent exposure to air at 1800° F. is given in Table VIII. Specimens coated with Coast Metals Modified 50 alloy and Colmonoy No. 5 alloy withstood 500 hr. exposure to air at 1800° F. after impacting without failure. The specimens that were coated with Al-Cr-Si alloy failed immediately.

The Al-Cr-Si coating could withstand the impact of the steel shot propelled at a velocity of 135 ft. per sec. In subsequent oxidation tests, the specimens sustained exposures at 1800° F. for 160 to 170 hr. before failure took place at the areas of impact.

The erosion test is very severe. The three coatings tested at 1800° F. were eroded away quite rapidly; failures occurred in 25 to 60 min. exposure to the hot-grit stream. The Al-Cr-Si coating failed after 25 to 30 min.; the Colmonoy No. 5 and Coast Metals Modified 50 coatings failed after 40 to 60 min.

Status of Proposed Coatings for Protecting Molybdenum

At this early stage it must be understood that each application presents special problems and any one of the proposed methods of protection would require specific development to be commercially feasible. The selection and development of a process for a specific application go well beyond the research phases so far covered. Such applied research must begin from the following considerations:

1. Alloying molybdenum to achieve universal oxidation resistance is still in the area of basic research.

2. It can be expected that in the near future metal cladding for molybdenum will be applicable to relatively simple shapes where the service temperature will not exceed 2000° F. and where maximum toughness of the surface is essential.

3. Protective surfaces of chromium and nickel-chromium alloys have been electroplated on relatively complex shapes. Such coatings have shown considerable promise for application at temperatures up to 2000° F.

4. Some sprayed coatings of complex composition are being developed which exhibit a degree of self-healing. Such coatings are less brittle than ceramics although less ductile than clad and plated coatings. They may give service up to 2400° F. and are applicable to relatively large and complex shapes.

5. At temperatures above 2400° F., where service will not involve severe thermal shock, mechanical impact, or high stresses, ceramic coatings and molybdenum disilicide coatings hold promise of long-time protection.

Rolled Metal Powder Sheet

*By LINCOLN T. WORK, JOHN D. SHAW, and WALTER V. KNOPP**

Good quality copper strip is being produced from roll-bonded copper powder. The powder is obtained by leaching low-grade copper-bearing scrap which cannot be remelted into ingot of good quality. (H 10, H 14, Cu)

A NUMBER of metals are becoming more widely available in powder form, and the extension of their usefulness into fabricated parts requires modified and new techniques. Standard powder-metal practices used in making such shapes are intricate and costly; in spite of this, they find advantages over still more costly alternatives. Methods adaptable to rapid, continuous forming of rod, strip and tubing from powder must be employed to take the place of the casting, rolling, and drawing practices now being used. One means of doing this is to compact loose powder into green strip or rod between rolls, sinter and reroll – using rolling and annealing to secure the necessary mechanical properties. The method is applicable to a number of metals and their alloys, both ferrous and nonferrous.

A technique developed by the Chemetals Corp., New York City, includes not only preparation of strip and wire from copper powder but also the recovery of the powder from low-grade scrap. The first installation using the process is a copper scrap plant, now in operation at Whitaker Metals Corp., North Kansas City, Mo. Economics has dictated the use of the lower grades of scrap which cannot be remelted into ingots of good quality. Furnace ashes from brass and copper operations, turnings, sweepings, clad iron scrap, motors and armatures, automobile radiators, and generally the number three and poorer grades are processed to yield top-quality copper as powder. Byproducts include zinc, tin, lead, nickel, and steel. In a business of this character the amount of powder which can be produced could glut the copper powder market quickly, forcing cost down so that prices should drop near to copper ingot prices. Copper powder now costs 13.75¢ per lb. more than copper ingot.

In this process, the scrap, freed of organic contaminants, is subjected to the leaching action of an alkaline cupric ammonium carbonate solution. Cupric ion is reduced to cuprous, while copper, zinc, and a few other metals, if present, are dissolved. The solution is oxidized with air to create more cupric ion, and suitable temperatures and agitation are employed to secure low leaching times (about 2 to 8 hr.). The selectivity of the alkaline ammonia solution limits the metals which can dissolve. Iron, lead, and tin are quite insoluble. Zinc is leached in substantial quantity. Cadmium, nickel, and cobalt will be rare in scrap and can be eliminated when present. The solution is purified to remove solids, colloids, and trace solubles of iron, lead, tin, silica, and man-

*Dr. Work is consulting engineer, New York City; Messrs. Shaw and Knopp are partners in S-K-C Research Associates, Paterson, N. J.

ganese. After leaching, it may contain over 100 grams per liter of copper – largely cuprous – and half as much zinc.

It is then reduced in an agitated autoclave at about 350° F., with a superimposed gas pressure of carbon monoxide or hydrogen of about 1000 psi. About half of the copper is precipitated as free-flowing powder of high purity. The autoclave is discharged, the copper separated from the mother liquor, washed and dried. The mother liquors pass on to the zinc removal stage where some of the zinc is removed to yield good-quality oxide or carbonate. The liquor is then ready for recycling.

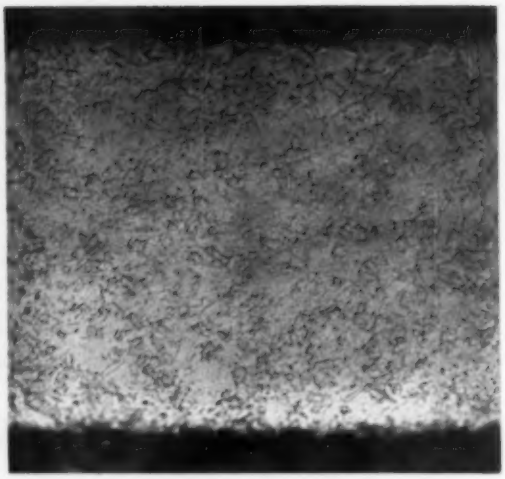
The powders produced by carbon monoxide reduction are coarse and tend to be spherical with a resultant high apparent density. Those reduced by hydrogen are finer and sharp, with very low apparent density. Tables I and II show typical properties of each. The hydrogen-reduced powders may be made more dense to approach the values of carbon monoxide-reduced powders.

The roll bonding operation is carried out by feeding freshly reduced powder from a hopper to rolls. These may be designed for roll bonding to either wire rod or to strip. The green strip possesses reasonable strength for light handling. Rapid sintering at high temperature develops much greater strength; additional rollings with intermediate annealing further consolidate and reduce the strip. There is marked advantage in shaping strip from powder to a thickness of perhaps three to ten times the final desired thickness; it eliminates the casting shop, heavy machinery for reducing large ingots, and the scrap loss of cropping and trimming. The properties of strip are as follows:

	Strip Thickness	
	0.0106 In.	0.0061 In.
Tensile strength	40,100 psi.	39,800 psi.
Elongation in 2 in.	34.0%	25.5%
Electrical conductivity (at 84° F.)	101%	101%

If the metal is kept clean and free from impurities and if it is worked by some reduction after consolidation, solid strip results. A section through copper strip rolled from powder is shown in the halftone.

Metals which have been roll bonded include copper, brass, bronze, iron, nickel, and silver. Many others can be so processed. Well-mixed powders can also be bonded and the alloys created in sintering by diffusion. This is particularly advantageous for metals of widely different melting points or of high volatility. Wherever segregation can occur during melting, the use of powder mixtures may give novel alloys.



Section Through Copper Strip Rolled From Powder (100% Dense). 250 ×

Table I – Properties of Copper Powder*

	H_2 Powder	CO Powder
Sieve Analysis		
+50 mesh	—	11.8%
−50 + 80	—	40.4
−80 +100	0.6%	17.0
−100 +150	4.4	19.0
−150 +200	7.9	8.1
−200 +270	10.3	2.5
−270 +325	28.5	0.8
−325	48.3	0.4
Apparent density, g. per cc.	1.20	2.64
Relative flow sec.	60.9	29.1
%	64.7	135

*Analysis: Cu, 99.953%; Pb, 0.001; Sn, 0.007; Ni, 0.001; Mn, 0.001; Fe, 0.003; Zn, 0%.

Table II – Properties of Copper Powder Compacts*

	H_2 Powder	CO Powder
Green density, g. per cc.	5.95	7.02
Sintered density, g. per cc.	6.67	6.85
Green strength, psi. (by transverse rupture)	4300	700
Sintered tensile strength, psi.	16,400	12,100
Elongation, % in 1 in.	10.3	7.75

*Pressed at 20 tons per sq. in.; sintered at 1000° C. for 1/2 hr. in hydrogen.

Continuous Casting

*By J. S. SMART, Jr.**

The experience gained with aluminum and copper alloys has helped develop continuous casting of steel to a practical production method. (C 5, D 9)

HISTORICALLY, molten metal, pure or alloyed, is the start from which we fashion our wares. Today we solidify our metals in a multitude of sizes and shapes by a variety of specialized methods which, broadly speaking, may be divided into two groups – one in which the product removed from the mold meets (or nearly meets) dimensional and appearance requirements, and the second in which a shape is produced for subsequent hot or cold working.

It is impossible to determine when dissatisfaction with conventional casting of metals led to the concept of casting them continuously. The manufacture of long lengths of lead pipe seems to have been the motive for the first documented description by John Laing of Bordentown, N. J., who was granted U.S. Patent No. 3023 in 1843. Sir Henry Bessemer undoubtedly did much more to stir up interest when, in 1858, he turned his attention to the direct casting of sheet from fluid malleable iron. His "Documentary", describing these experiments and stating his belief in the practicality of the process, has been neither forgotten nor ignored, but the direct casting of sheet and strip is so difficult that it has not been achieved commercially today, almost 100 years later.

By the turn of the century, a surprisingly voluminous patent literature had come into being, describing devices to increase rate of cooling, lubrication for the mold, reciprocation to prevent sticking, mold tapers, and protective atmospheres, which showed clearly that men were coming to grips with the problems involved.

Thus the stage was set for the early 1930's when work in pilot plants was intensified in the nonferrous industry. Before the decade was over, three different processes were in operation on a commercial basis, making "intermediate" shapes of high quality, two in the United States and one in Germany. Since then progress has been both rapid and diverse. The practices now in use in the United States are representative of many of the successful techniques and illustrate many of the practicable solutions.

In the article to follow, three methods for casting the light alloys will be described (Alcoa's D.C. process, Properzi's wheel, and Hunter-Douglas Corp.'s horizontal strip caster); three methods for casting copper and its alloys (the Asarco process with which the present author is identified, the Welblund-Benard or Inco process, and the Junghans-Rossi process); and finally two approaches to the continuous casting of steel, including the last-mentioned process as adopted by the Allegheny Ludlum Steel Corp. and Atlas Steels, Ltd., as well as the Babcock & Wilcox practice.

"D. C." Process for Aluminum

The performance record of the "D. C." or direct chill process and its influence on the aluminum industry have been remarkable. It was introduced in 1935 by the Aluminum Co. of America following investigations by Wm. T. Ennor and his associates.

Aluminum ingots were formerly produced in cold molds by several techniques designed to prevent turbulence and entrapment of the ever-present oxide skin into the body of the casting, as well as for directional solidification. Better dispersion of secondary constituents was obtained by the "water dipped" process in which a hot mold was gradually lowered through a water spray to insure a narrow solidification

*Assistant to Vice-President and Director of Research, American Smelting and Refining Co., South Plainfield, N.J. The author acknowledges the indispensable help of a large number of friends who have been intimately connected with various phases of the problem. A much more lengthy discussion was presented to the Australian Institute of Metals as its third annual lecture, June 1, 1954.

zone. However, these methods were limited to rather small ingots; the nonuniform dispersion of secondary constituents was particularly troublesome, causing cracks in both the early and advanced stages of fabrication.

The D. C. process provided nonturbulent flow of properly conditioned metal into the mold; a short, controllable solidification zone, and a high degree of chill by water sprays on the casting emerging from the short mold. Ennor's process was the first continuous casting method of major importance and is also the only one to have been adopted as standard by the industry. During 1953 it is estimated that more than 120 units in the United States cast more than 3½ billion pounds of metal.

The ability to produce large ingots has had a profound effect on the industry. At Alcoa's Davenport mill, ingots 12 × 48 in. in cross section are cast in lengths of 136 in., weighing as much as 7800 lb. A wide variety of solid and cored extrusion billets and forging and rolling ingots are cast at rates from 1½ to 7 in. per min. in various multiple arrangements that may include as many as 14 billets on a single platen.

The continuous casting of large shapes depends on the rapid formation of an initial skin or shell. Since, in many processes, the shell is in motion even in its embryonic state, it must be strengthened by further rapid cooling to withstand frictional forces and the reheating effect of the interior molten metal. Inevitably, the steep temperature gradients produced thereby cause large internal stresses. In D. C. cast aluminum alloys these, if uncontrolled, can split the ingot from end to end. Consequently, any change that demands more rapid heat extraction, such as larger cross section or casting rate, will increase the possibility of internal cracking. Higher strength alloys are more likely to crack, so size limits vary with composition. Casting rates are as slow as 1 in. per min. on 20-in. rounds or larger sections.

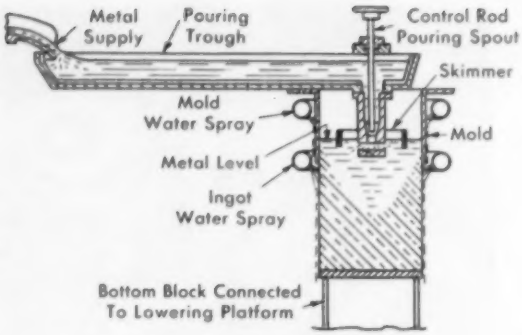


Fig. 1 – Sketch Showing Principle of Direct Chill (D. C.) Casting Process Used for Aluminum and Magnesium Alloys

Low-melting phases bleed through the dendritic structure of the skin where there is initial shrinkage from the mold wall. These brittle exudations must be removed by scalping. Other casting processes have the same problems and for the same basic reasons. Actually, the D. C. process, by its mechanical simplicity, provides a most favorable opportunity for altering mold materials, internal tapers, lubrication, and spray arrangements to achieve optimum results.

Although the *concept* of the casting procedure is continuous, the *equipment* is usually operated discontinuously. With a solidification rate of 25 tons per hr. when casting 12 × 48-in. sections in multiples of three, downtime may lower the average output to about 6 tons per hr. What then



Fig. 2 – 1-Ton Slab of Magnesium Being Hoisted Out of Casting Pit. Descending casting is at rear, prior to being cut to length

are the possibilities of adopting continuous operation?

This would require either the elevation of the entire metal supply system, or a large and deep pit. A massive roll drive and sawing machine would be needed as well. Furthermore, the imposing size of the ingots would severely limit multiple operations on many shapes due to the difficulties of sawing more than one at a time. Thus, the question becomes one of continuous duty with a large unit versus sheer numbers of small simple units.

With this in mind, a balance sheet would include at least the factors shown in Table I.

The intermittent operating method has been specified for recent new plant construction. It can readily turn out small tonnages as well as serve the largest plants in existence.

On the other hand, a truly continuous machine casting large ingots has a gargantuan appetite for molten metal that must be satisfied. However, a small, continuous Rossi machine is in operation in a horizontal position at the Southern Electrical Corp.'s plant at Chattanooga, Tenn., making 2¼-in. billets for wire rod.

While it seems certain that new alloys and larger sizes will require further modifications, the D. C. process will probably retain its reputation as the work horse of the trade.

Magnesium

In 1938, the Dow Chemical Co. started laboratory work on the continuous casting of magnesium and several years later installed a D. C. process with provision for continuous operation.

Magnesium is easily melted and the molten metal can be readily pumped about through steel pipes. Thus, individual melting pots can be operated in a staggered cycle to supply a constant-level casting pot, and the metal level in the mold can be controlled by automatic regulation of the pump.

These factors favored continuous operation, as did the fact that an atmosphere of sulphur dioxide is required to protect the molten surface from oxidation. Furthermore, certain alloys are prone to crack at the start of casting which would add to cropping losses in the intermittent method. The first unit began operations in March 1943 on 12-in. extrusion billets. The molds are preferably made from copper, and cooled by water sprays. Molten metal is pumped in at 1300° F. through a resistance-heated pipe and distributed uniformly by a baffle plate located just below the exit. Rubber wipers strip most of the cooling water from the solid ingot prior to the roll drive, and the remainder is removed by other wipers just ahead of the saw. The flying saw starts when the casting intercepts a beam of light. Dual molds are employed for the multiple casting of sections up to 8 in.

Analytical control by direct-reading spectrograph, and instruments to record the casting variables are part of an over-all quality control. All rolling ingots and most extrusion billets are scalped to depths of ¼ to ⅜ in. Dow Chemical Co. is now casting 11 × 41-in. rectangular sections and rounds up to 18 in. — probably the largest cross sections cast on completely continuous machines in the entire metals industry.

Table I — A General Comparison of the Merits of Intermittent Casting Versus Continuous Operation on Aluminum Alloys

Factor	Intermittent	Continuous
Metal supply	Can be in batches at ground level	Must be continuous and requires elevation or deep pit
Multiple operation	Three or more on large sizes; up to 14 on small sizes	One on large sizes; about four on small sizes
Materials handling	Simple	Relatively complicated
Lubrication of mold	After each cast, or continuous	Must be continuous
Control of casting	Good, but requires skillful operation of each cast	Excellent; adjustment can be maintained continuously and altered during operation
Surface exudations	Present	Present
Internal stresses	Present; scrap losses 1 to 2%	Present; sawing operation an additional factor; continuous operation favorable to adjustment
Metal yield	Some losses at both ends	Excellent; no end losses
Capital investment	Low	High
Adaptability	Excellent	Good

The Properzi Process

For many years various solder manufacturers have poured fusible alloys into small round grooves cut into a rotating cast iron drum to obtain rods that could be rounded up in wire machines. Ilio Properzi of Milan has used the same approach in his scheme that uses a wheel with a water-cooled rim in which is cut a triangular groove. An endless belt of low-carbon steel closes the mold cavity into which the molten metal is poured. As the drum revolves, the rod is carried through a water trough, then separated from the belt and on to a 12-stand tandem mill, designed for the unusual triangular cross section, and is taken off as finished wire rod.

While originally set up to provide lead wire for the manufacture of shot, and then used for zinc as well, its greatest application by far has been for the continuous production of aluminum wire rod for electrical conductors. In the United States alone, seven such machines have been installed since 1949, and another on various aluminum alloys for general purposes. The machines are relatively inexpensive and can convert wire mill scrap into usable rod stock at reasonably low cost. Originally, the metal was fed through a cast iron tube to the cavity and the level controlled by observing the heat pattern on the steel band. Newer models have larger grooves so the metal level can be seen by the operator.

On the Properzi casting wheel the mold and the casting are in prolonged contact. We believe this is particularly beneficial to the casting of small cross sections at high rates. Larger sections would quickly shrink away and lose the chill.

Numerous improvements have been made. The feeding spout, originally of cast iron, has been replaced by alloy iron or a compressed asbestos mixture, but the life as yet does not exceed 4 to 6 hr. This will undoubtedly be improved. Transverse heat checks develop in the copper rim after 500,000 to 1,000,000 lb. have been cast, but despite this, mold life runs up to 3,000,000 lb., depending on the requirements of surface quality.

Troubles may arise from oxide inclusions and piping or shrinkage at the center. A metallurgical situation, quite unrelated to the casting process, also has to be considered in making electrical rod. Conductivity is lowered by soluble impurities, and the high rate of chill promotes their retention. Corrective heat treatments would interrupt the continuity of the process, so

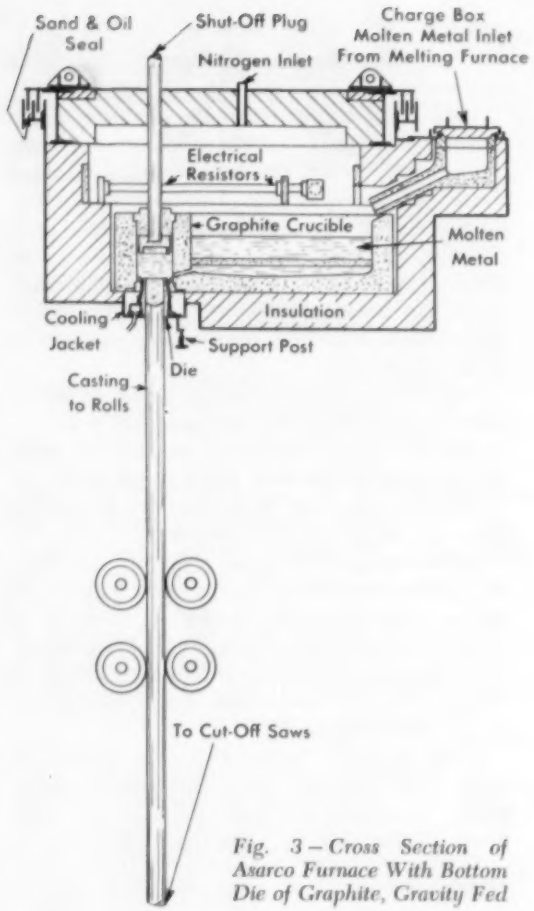


Fig. 3 – Cross Section of Asarco Furnace With Bottom Die of Graphite, Gravity Fed

primary aluminum producers are helping with special grades of pig suitable for use on these machines. At present, 1100 (2S), 3003 (3S) and 3004 (4S) alloys are being cast, and 6061 (61S) has been tried, and the Properzi machine will undoubtedly earn a firm place in rod production.

The Hunter-Douglas Process

About 1915, Grenville Mellen constructed and operated a prototype employing mating half-mold sections carried on two endless belts, so arranged that a continuous vertical cavity was formed by the cooperating sections. They were cooled while disengaged.

The machine was operated commercially on brass rod for several years in Garwood, N. J., and then abandoned. Apparently, Mellen was born 30 years too soon.

A very successful arrangement was designed by J. L. Hunter and consists of two continuous "belts" forming a horizontal cavity when en-

gaged. Mold segments are heat treated alloy cast iron, continuously cooled with interior water passages, joined by hose connections to water distributors turning on the axis of rotation of the "belts". Equipment is precisely constructed and dimensional stability is maintained, despite a little heat checking and a few fatigue cracks. Aluminum alloy is melted in an Ajax furnace, stored in a gas fired reverberatory and carried to the machine through open launders. The pouring tip delivers metal to the mold cavity by gravity and it is built so as to prevent back flow. Since it is supplied from below the metal surface in the launder, oxides are effectively held back.

Metal entering the mold is chilled rapidly, as indicated by typical columnar structure. (In practice, however, 0.03% titanium addition produces a fine grain.) Feeding at the center-line must be horizontal. Occasional shallow depressions due to shrinkage are readily eliminated in hot rolling.

The strip emerges from the diverging mold blocks at 750 to 1000° F., is cut to length and hot rolled on a tandem mill. A 450-lb. coil of ¾-in. strip is made in about 1 min. without edge rolling. Cold rolling is followed by the usual finishing operations. In the special alloys for which it is used, as well as for alloys up to the general complexity of 2014 (14 S), no difficulties have been encountered with internal stresses. In addition, the surface needs no scalping. These add up to an impressive achievement in casting quality.

The Hunter-Douglas process obtains a high linear casting rate by providing maximum time of contact of a relatively small cross section with a chilled mold surface. It is doubtful whether the section thickness could be increased to 6 in., for example. On the other hand, provided the thickness were not increased too much, a substantially wider strip could be cast. Small-diameter rods and other shapes may also be distinct possibilities.

Essentially then, the Hunter-Douglas process is a fairly inflexible method for mass production of strip and other small sections where large tonnages are required for a limited number of products.

The Asarco Process

Let us now leave the light metal field and consider the very interesting progress that has evolved in the casting of copper and copper-base alloys. In America commercial success was reached in 1937 when the American Smelting and Refining Co. began operating four machines casting 3-in. phosphorized copper billets for piercing.

The furnace and mold (or die) are in one unit, as shown in Fig. 3. The furnace has a welded steel shell, is lined with insulating brick and heated by a grid of graphite resistors. Molten metal enters at one end through a closed launder, periodically supplied from a ladle car.

A large crucible machined from a solid block of graphite and set into the bottom of this furnace provides both a holding chamber for deoxidation, and a smaller casting chamber fed by drilled passages. The casting chamber is cylindrical with threaded end to fit mating threads on a graphite die. About this die is mounted a water jacket. After a starting tip is inserted to close the die, hot metal is run into the furnace;

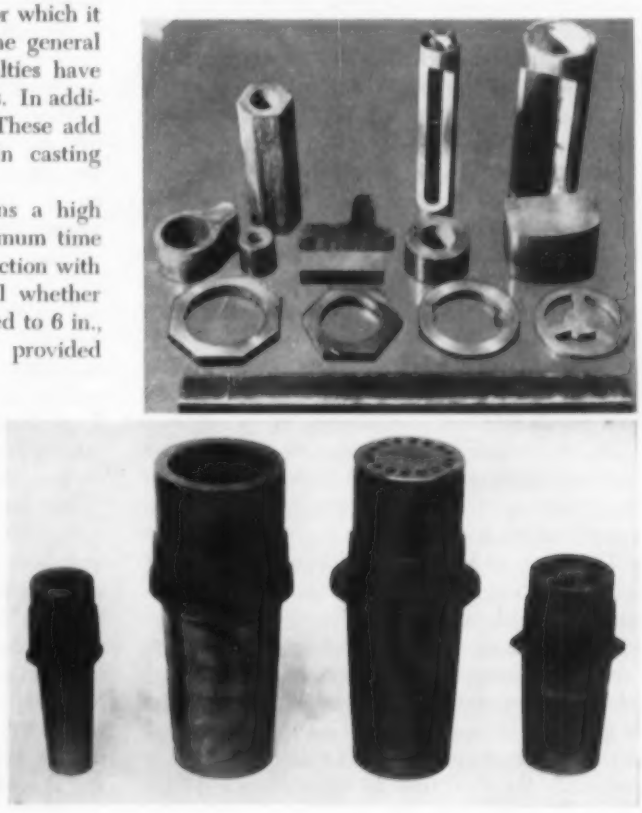


Fig. 4 — Representative Types of Graphite Dies (below) and Shapes of Bars and Tubing Regularly Cast in Copper and Copper Alloys

a fusion weld is obtained with the tip which is then slowly withdrawn, leading freshly cast metal out of the furnace. To facilitate starting, the top of the die extends several inches into the bath; it carries a slightly converging internal taper in this portion to compensate for expansion. Compound tapers are used at and below the freezing zone to follow the contour of the shrinking casting.

Apparently, there is a widespread belief that graphite dies diminish cooling rate and interfere with rapid solidification. This overlooks the fact that no insulating film (such as lubricant) separates molten metal and die. Furthermore its wall thickness seldom exceeds 5/16 in. Actually, exceptionally high over-all heat transfer rates are achieved. The jacketed length of the die is only 5½ in. and the billet is usually completely solid before emerging. This short freezing zone is especially valuable in eliminating porosity; densities of 8.90 to 8.92 are readily obtained in comparison to 8.93 for wrought copper.

Die life varies with quality of the high-density, fine-grained graphite; for copper billets it averages about 72 hr. with maximum of 120 to 140 hr. The die gradually etches enough to cause a variation in surface finish of the billet.

As applied to copper billets, the Asarco process is completely mechanized. All operations, including sawing to length, are carried out automatically, except the necessary periodic additions of molten metal to the furnaces. This is possible because the die is fed by gravity and does not require manual regulation of a metal stream.

After several years of operation we tried to raise the output beyond the original rating of 1000 tons per month. Existing melting capacity and the physical limitations of the building were found to limit the total output to 1400 to 1500 tons per month. Operations have continued on this basis up to the present time, producing well over one-half billion pounds of billets.

By 1943 it had become evident that the process was unusually versatile and pilot plant operations were started on alloy products in a wide range of sizes and shapes.

This program led to the casting of tubing, using self-lubricating tapered graphite mandrels (uncooled) which maintained concentricity within 1%, and of many special shapes such as squares, rectangles, hexagons and octagons. For these, real advantage was taken of the fortuitous properties of graphite. Its excellent machinability permitted die manufacture in wholesale quantities. Its low cost made the short runs an economic possibility. New die designs could be tried daily without prohibitive expense.

Initially, these advances were applied to the casting of high-purity silver anodes, but leaded and nonleaded phosphor bronzes received the major amount of attention. In 1947 a completely new plant was opened for their manufacture on a custom basis.

In this operation each of six casting furnaces is supplied with molten metal by Detroit electric arc furnaces. There are two sizes of casting furnaces to accommodate a standardized series of dies and jackets with a diameter range of 7/16 in. minimum to 5¾ in. maximum. New roll drive designs were able to handle the various sizes as well as multiple casting of the smaller sections — two, three or five strands from a single die.

The controlled solidification offers a most convenient way to overcome porosity and shrinkage so commonly encountered in casting bronzes. Moreover, the physical properties and the dispersion of the secondary constituents in both the leaded and nonleaded varieties are greatly enhanced by the drastic chill. High-quality shapes in long lengths have had a most favorable acceptance from fabricators. Such products, cast to normal brass mill dimensional tolerances from the so-called foundry alloys, are especially useful, since they can be machined on automatic screw machines at high production rates.

Thus, in its field of application, the Asarco process has realized the objective of direct conversion of molten metal to finished mill products on a continuous basis and with improved properties.

The Wellblund-Benard Process

This process was originally developed and installed at the International Nickel Co. plant at Copper Cliff, Ont., to cast copper wire bars, and hence is sometimes called the Inco process. Two similar machines have been used by the American Metal Co. at Carteret, N.J., for casting oxygen-free, high-conductivity refinery shapes.

The mold is a chromium-plated copper block with drilled water passages, split longitudinally, and both halves are vibrated 0.005 to 0.010 in. about 1200 times per min. Oxygen-free copper from a "Scomet" furnace is poured through a hooded funnel and refractory nozzle, all enclosed in a reducing atmosphere. A small stream of hydrocarbon gas is directed to the liquid level where it dissociates and serves as a lubricant. The casting leaves the mold at a high temperature and is cooled by water sprays. The surface of the

casting is good and requires no overhauling.

The performance on copper, at a rate of 1½ to 2 tons per hr. for a 4 × 4-in. cross section, is equivalent to that of any other process. However, the Inco process has not as yet been developed to its maximum potential.

The Junghans-Rossi Process

This most successful process for continuous casting of nonferrous metals was invented by the German, Siegfried Junghans. In 1938 patent rights were acquired by Irving Rossi, and Scovill Mfg. Co. started casting brass extrusion billets with a German-built machine. Seven machines have since been installed in the American brass industry.

The basic Junghans design has a thin-walled copper mold, while the Rossi models are fabricated from solid copper blocks, chromium-plated. Molds can be machined from solid sections if short, or use separate copper liners if long. Since the solidifying section shrinks away from the wall, the use of 24-in. long molds and direct water sprays has been preferred to very long molds. In any event, the heat removed by the mold and by the sprays can be varied within a wide range.

One of the distinguishing features is a vertical reciprocation of the mold – a principle which is actually quite old, being patented in 1914 by Pehrson and in 1921 by Van Ranst, both pointing out the advantage of avoiding any binding between casting and mold wall. The motion suggested by Junghans insures no relative movement of mold and solidifying section during most of the casting period, by synchronizing speed of casting and downward stroke of the mold for about ¾ in., followed by a rapid return.

This reciprocating motion also helps distribute the lubricant along the segment of the mold wall where the skin is first frozen. For brass, sperm oil is delivered through small copper tubes; cracking of the oil forms an oily carbonaceous coating in addition to a fluid film.

Junghans-Rossi machines are especially useful for extrusion billets and rolling slabs of fairly large cross section. The space for spray cooling below the mold, in addition to a roll drive, saw, and unloading facilities, requires both a heavy structure and massive equipment. This major investment cannot be utilized efficiently unless the machines receive the large amount of metal they can handle. Consequently, they are most useful in mass producing standardized shapes.

Scovill's new integrated strip mill is an excellent example of how these features have been combined to advantage. It was described at length in *Metal Progress* for January 1950. Historically, this company has favored the cold rolling of brass in preference to the recent tendency for hot breakdown. The development of slab casting following the success of their first Junghans-Rossi billet machine enabled the design of a new straight-line mill of the most modern type for the production of cold rolled strip in long lengths. Three Ajax-Scomet furnaces provide molten metal to a pouring furnace containing a high-chromium-iron delivery tube; the stream is regulated by a tapered control rod.

The popular slab is 26 in. wide, 2¾ in. thick and 10½ ft. long. The mold is 25 in. long and at the reported production rate of 20,000 lb. per hr., water sprays have not been required for this relatively thin section. No difficulties have been encountered in producing 2000-lb. slabs to good dimensional tolerances and the lead-free alloys are characterized by excellent surface. The problem of surface quality in the leaded brass has been more difficult; this is of no consequence to extrusion billets, but is an important factor for slab metal.



Fig. 5 – Slab Ingots of Brass, Cut to Length, on Run-Out Table in Scovill's Continuous Strip Mill. In background a slab, freshly cut from the descending continuous ingot, is being tilted down to horizontal

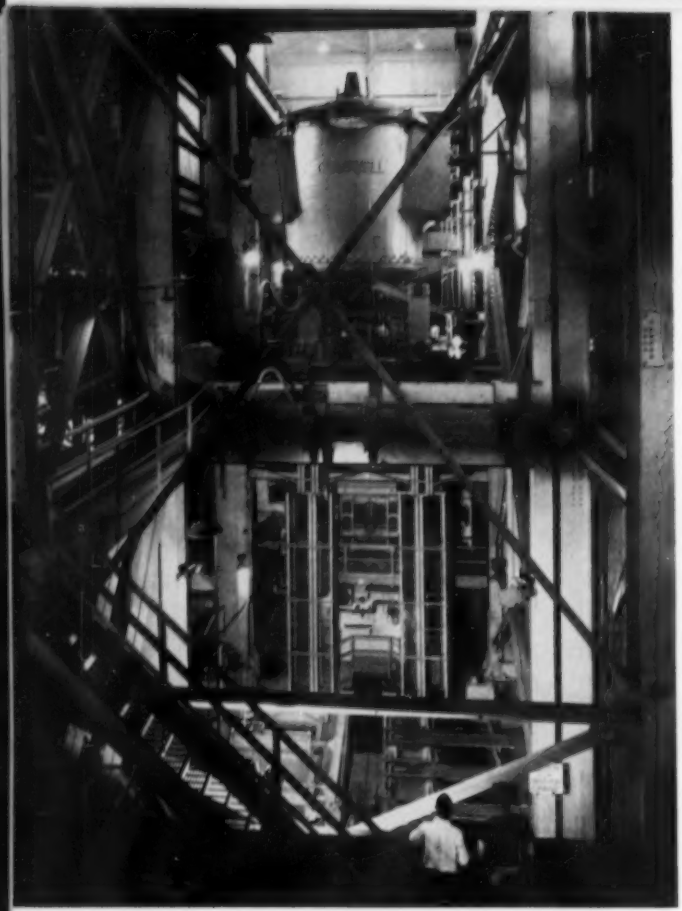


Fig. 6 – Side View of Tower-Like Casting Department at Atlas Steels, Ltd. A ladle of molten steel at top tilts into tundish; steel then enters short mold and is withdrawn steadily downward through water sprays and a set of hold-up rolls, is cut to length by oxy-acetylene flames, and run out at bottom while still visibly hot

Continuous Casting of Steel

The Junghans-Rossi success in the copper and brass industry reawakened interest in the problem of continuously casting steel. It will be recalled that Bessemer may have made the first actual run using malleable iron. It is certain the American steel companies have never lost interest, despite the fact that until recently all attempts eventually received quiet and presumably decent burials.

Yet continuous casting looks so easy (when it works) and is so intriguing a prospect that it has always bounced back. Despite earlier disappointments, the Allegheny Ludlum Steel Corp. has been working with an experimental Rossi machine patterned on those used for brass since 1949 at Watervliet, N.Y. A 5000-lb. Ajax high-frequency furnace serves both as a melting and pouring unit.

Such work has recently received great impetus from a commercial installation at Atlas Steels Ltd. of Welland, Ont., particularly since the slab castings are rolled to finished sizes in hot and cold Zendzimir mills of the planetary type. (This new mill was briefly described in "Critical Points" in *Metal Progress* for November 1954.) Withdrawal rates are already as high as 50 to 60 in. per minute on 5.5 × 7.5-in. sections.

Reciprocating motion of the mold* has been as useful in these two units casting steel as it has been for brass. The mold now at Watervliet is 24 in. long, machined from a solid block of copper; vertical water passages contain a concentric constrictor rod to increase the velocity of water flow, which varies from 80 to 200 gal. per min. The working face is coated with 0.003 to 0.005 in. of hard chromium plate and is lubricated with rape seed oil. The molds used at Welland are similar, but 2 to 4 in. shorter.

Molten steel does not flow easily through tubes nor can it be regulated by valves. In fact, it is difficult to find an ordinary orifice that will resist the cutting action of the stream. Under such conditions, the simple things that work are the most effective aids to success. A free-falling stream feeds the mold, delivered from a stabilized zirconia nozzle mounted in the bottom of a tapered tundish which catches the flow from the tilting furnace. Oxidation is prevented by burning propane.

The linear speeds are high compared to equivalent nonferrous sections. Withdrawal rates are on the order of 30 to 60 in. per min. Consequently, the section leaves the mold at a very high temperature and must pass through many water spray rings before it reaches the roll drive. The objective is to form only a thin shell in the mold and to extract the remaining heat by water. The shell of a 5-in. round may be only ¾ in. thick at the bottom of the mold and the molten core may extend down the bar as much as 10 ft. Consequently, the mold itself may extract only part of the liquid superheat, less than 20% of the total latent heat, and only a very minor part of the sensible heat.

These are favorable conditions for high pro-

*Editor's Footnote – Work at British Iron & Steel Research Assoc. indicates that the thin steel shell sticks occasionally to the mold and is then likely to crack. These cracks will heal promptly if there is no relative motion between mold and descending steel shell. This has led to a design wherein the mold is merely mounted on springs, and it is in semi-commercial operation in Sheffield casting toolsteel billets.

duction rates. In addition, the high melting point of steel is no disadvantage; on the contrary, the high temperature gradient between liquid and mold wall insures greater heat extraction. Steel's low thermal conductivity, particularly at elevated temperatures, seems to be the limiting factor as to production rates.

Unfortunately, rapid cooling can also result in very high stresses with damaging effects. Rounds have a tendency to flatten, while rectangular shapes may have dished-in sides. (Molds with distorted contours have been helpful in avoiding this.)

Interior cracking is more serious. It invariably results from excessive volume of spray water. Furthermore, the permissible volume varies within wide limits for different compositions. Successful casting also depends upon a speed high enough to avoid cold shuts, and complete solidification prior to the roll drive.

Atlas Steels expects to cast the majority of its tonnage of stainless steels in 5⅛ × 21½-in. slabs cut 17 ft. long. However, square and rectangular sections will also be cast for other products in the tool, valve, and stainless steel line. Atlas has forecast improvements in yields that would amount to 3¢ per lb. for stainless, 8¢ for valve steel and 20¢ per lb. for high speed steels — figures far in excess of any possibility in the copper industry.

Babcock and Wilcox Practice

In 1946, Republic Steel Corp. and Babcock and Wilcox Tube Co. combined their efforts on the continuous casting of steel. Under license from E. R. Williams, a pilot plant was constructed at Beaver Falls, Pa., and 4 × 2½-in. ovals were successfully cast in 1948 from an induction heated pouring ladle, a lip-pouring induction heated tundish, and a long mold topped with an argon atmosphere.

The mold was a brass tube (¼ in. or less thick) as long as 108 in., cooled by high-velocity turbulent flow in an annular space of about ⅜ in.

Early difficulties arose from the warpage in long tubes (molds) of this thickness. Castor oil was the lubricant and an X-ray beam traversing the mold located and controlled the metal level.

As reported in *Metal Progress* for March 1953, this plant is equipped with a 7-ton arc furnace pouring into a tundish having three slag skimmers. Lip pouring is preferred to bottom-pour nozzles. Oval sections have now been replaced by 7-in. squares which are rolled to rounds for piercing.

The Babcock and Wilcox stationary mold can probably extract more heat per unit area from the *mold wall* to the water film than the Rossi type. However, the reciprocating motion tends to minimize this difference. The Rossi mold is short in order to gain direct cooling by means of water sprays; the Babcock and Wilcox mold is long, and probably shell shrinkage is followed by reheating from the still-molten interior and recontacting the mold wall in a cyclic pattern. Both the Babcock and Wilcox and the Atlas machines are working at roughly comparable production rates.

The Hazelett Process

For a long time C. W. Hazelett tried to cast strip metals between chilled rolls as originally proposed by Bessemer. Various modifications of his equipment were tried by several companies. Serious difficulties were never solved, such as gage control, tendency to freeze more rapidly at the edge dams, segregation in alloys, and roll maintenance.

Recently a new concept has revitalized the work, in the use of two thin endless moving steel belts to form a sandwich for the molten metal while it is cooled by water sprays. About 500 different spray designs were tested before the entire belt area was properly cooled.

Supporting rolls allow the lower belt to receive the stream while in the shape of a shallow trough and then to flatten out the depression into a strip of controlled dimensions. Full advantage is taken of the principle of the moving mold, and strip ⅛ in. thick is cast at high rates — too high, in fact, for comfort. Experimental machines are said to be working on aluminum, magnesium and brass.

In addition, rumor also has it that Armco has a machine which has produced ⅛-in. strip steel, pouring a 1-ton ladle in 1 min.

In all probability, no other news item could better illustrate the vitality of continuous casting. The advantages that it basically offers in higher quality, better yields, economy and comfortable working conditions are too tempting to be ignored. Consequently, there is every reason to believe that progress in this challenging field will continue to flourish. It is now certain, also, that a wide variety of processes are not only useful, but necessary to meet the specialized and diverse requirements of the metals industry. Our application and further development of present methods and newer techniques seem to be limited only by our ingenuity

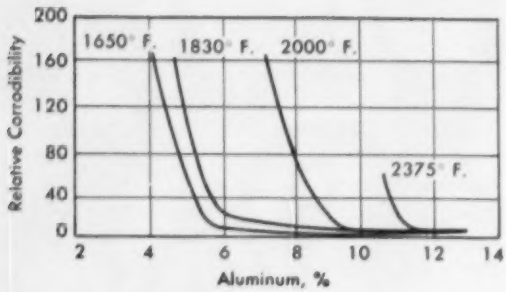


Fig. 1 – Relative Oxidation Resistance of Iron-Aluminum Alloys

Ductile Iron-Aluminum Alloys

*By ERIC R. MORGAN and VICTOR F. ZACKAY**

Ductile iron-aluminum alloys with oxidation resistance and high-temperature strength equivalent to conventional stainless steels can be produced by vacuum melting. (Q 23, R 2, D 8, SG-h)

THE ADVENT of heat engines operating at higher temperatures has focused attention on the development of refractory metals and alloys. Unfortunately the improved hot strength of these new alloys has been accompanied by a sharp rise in alloy content.

Both austenitic and ferritic steels are used at high temperatures. Austenitic alloys have excellent hot strength, good ductility over a wide temperature range, satisfactory oxidation resistance up to 2100° F. and adequate corrosion resistance. A major drawback to their large-scale use, as in a mass-produced automotive gas turbine engine, would be the serious drain on strategic and costly elements such as nickel and cobalt. Ferritic alloys, on the other hand, generally suffer from low hot strength, mediocre room-temperature ductility and relatively poor fabricability. However, their oxidation resistance is often superior to that of the austenitic alloys. Furthermore, this superiority is gained by the use of noncritical and inexpensive elements such as chromium, silicon and aluminum.

Clearly then there is a need for ferritic alloys possessing, in addition to their usual high oxidation resistance, sufficient room-temperature ductility for ease of fabrication, and improved hot strength. As part of the experimental program of the scientific laboratory of the Ford Motor Co., a ductile, nonstrategic iron-aluminum alloy has been developed known as "Ferral". It has excellent oxidation resistance and can be fabricated by ordinary methods. In its modified heat resistant form it has creep-rupture properties equivalent to the austenitic stainless steels.

The excellent oxidation resistance of iron-aluminum alloys reported by C. Sykes and J. W. Bampfylde (*Journal* of the Iron and Steel Institute, Vol. 130, 1935, p. 389 to 418) is shown in Fig 1. The values of "relative corrodibility" are obtained by dividing the losses in weight of each oxidized alloy by the weight lost by the most resistant. It is apparent that aluminum in excess of 8% is necessary for adequate oxidation resistance above 1800° F.

The appearance of alloys oxidizing at very high temperatures varies with aluminum content. Alloys low in aluminum have a dense, black scale, those with intermediate aluminum (8 to 12%) exhibit a reddish-white adherent film while the alloys with over 12% aluminum have a fine, white, aluminum oxide powder over a dull metallic surface. The effect of varying aluminum

*Respectively assistant manager of the scientific laboratory, Ford Motor Co., and research engineer in the metallurgy department of the laboratory. The authors gratefully acknowledge the assistance and cooperation of the heat treat subcommittee for the service tests of Ferral.

content can be judged visually from the samples shown in Fig. 2. At the 6% aluminum level significant scaling is apparent at both 1900 and 2100° F., but the 8% aluminum alloy is relatively unattacked.

Attempts to evaluate quantitatively the oxidation resistance by the cathodic descaling method failed with alloys containing more than 8% aluminum but indicated that 8% aluminum alloys are equivalent in oxidation resistance to Type 302 18-8 stainless steel. Above this aluminum level the iron-aluminum alloys are superior to most commercial austenitic steels and this superiority increases with increasing service temperature. A typical example is shown in Fig. 3. A cylinder of 14% aluminum alloy and a similar specimen of Type 316 were exposed side-by-side in air at 2300° F. for 80 hr. The severe swelling and blistering of the stainless steel occurred in the first few hours while the iron-aluminum alloy was practically unaffected at the end of the test.

At least 8% aluminum is required for appreciable oxidation resistance at 1800° F. or more. Unfortunately, alloys containing more than 5% aluminum have in the past been brittle at room temperature. This lack of ductility has seriously retarded the use of these alloys.

The extreme brittleness of early iron-aluminum alloys was attributed to the presence of impurities, principally oxygen. Although such alloys were melted under protective slags the oxygen content was sufficient to cause embrittlement.

The first step in reducing the oxygen content was to melt in stabilized zirconia crucibles under high vacuum. Hot workability immediately improved for alloys containing up to 17% aluminum but room-temperature brittleness and ingot unsoundness (microcracking) remained perplexing problems.

The next step was to develop a simple and effective technique to reduce the oxygen level significantly below that obtained by vacuum melting alone. Two conventional methods of deoxidation appropriate to vacuum melting – carbon and hydrogen reduction – were evaluated. Hydrogen should be the more effective of the two but it is potentially explosive, especially at elevated temperatures, and the process is relatively slow and costly. It requires 4 hr. to reduce oxygen content to 0.0015% with hydrogen. By contrast, carbon additions supplemented by high vacuum can reduce the oxygen level to about 0.001% in 10 min.

The simplicity, efficiency and safety of carbon

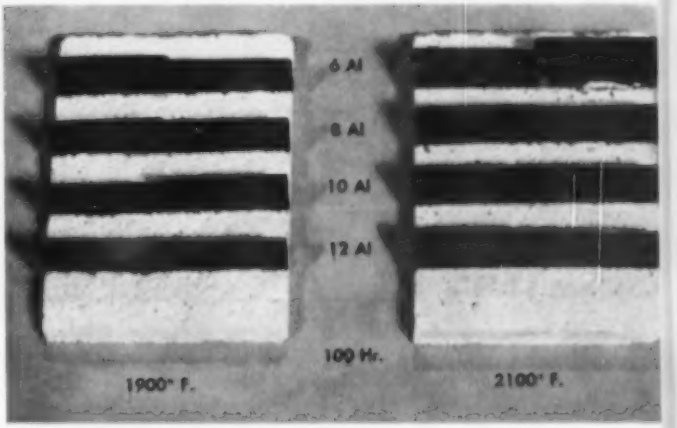
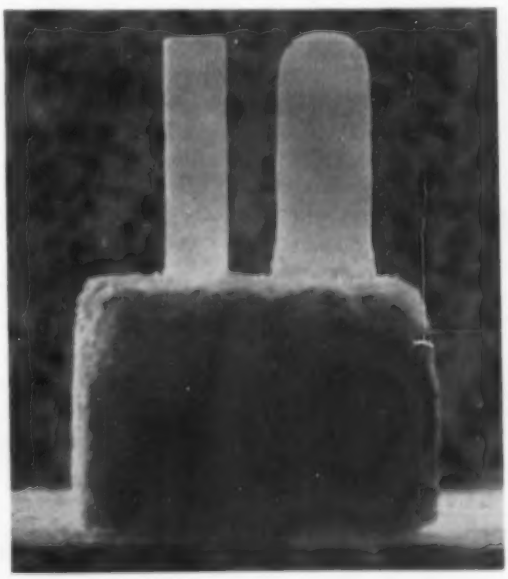


Fig. 2 – Effect of Aluminum on Oxidation Resistance of Iron-Aluminum Alloys

reduction had led to its adoption as standard procedure. A maximum carbon content of 0.03% has proved adequate for efficient deoxidation while still retaining high impact ductility. Carbon in excess of 1% does not seriously alter the hot workability but cold working is very difficult for carbon contents greater than 0.15%.

Several hundred iron-aluminum alloys of widely varying composition have been prepared and evaluated. A measure of the progress made in improving the ductility is illustrated in Fig. 4.

Fig. 3 – Samples of 14% Al Iron and Type 316 Exposed in Air for 80 Hr. at 2300° F.



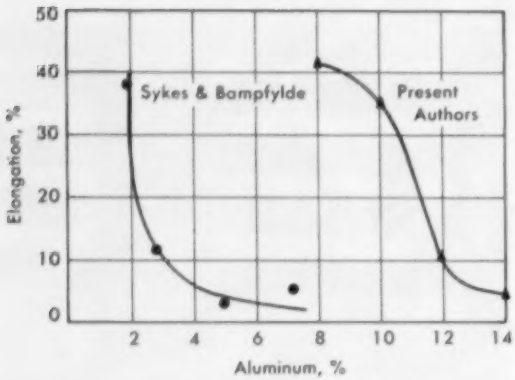


Fig. 4 – Effect of Aluminum on Ductility

The variation of elongation with aluminum content is shown for the alloys prepared by Sykes and Bampfylde and those of the present authors. In the earlier work the sharp drop in ductility occurred at about 5% aluminum. An analogous decrease in ductility appears in the alloys of the present investigation at about 10% aluminum.

Careful control of alloy composition, melting procedure, and fabrication techniques is necessary to produce these ductile vacuum-melted alloys. The same approach to the air melting of iron-aluminum alloys has produced encouraging results.

The hot strengthening effect of many elements has been evaluated for iron-aluminum alloys, principally by creep-rupture tests. The results may be briefly summarized by stating that titanium and silicon produce the best increase in creep-rupture life. For example, the creep-rupture characteristics of 8% and 14% aluminum alloys with 3% titanium are shown in Fig. 5, on a Larson-Miller plot*, where stress is plotted against a parameter involving temperature and time-to-rupture. For convenience, vertical lines are shown in color defining the 100-hr. rupture life at the indicated temperatures. The creep-rupture life of Type 302 austenitic stainless steel is included for comparison.

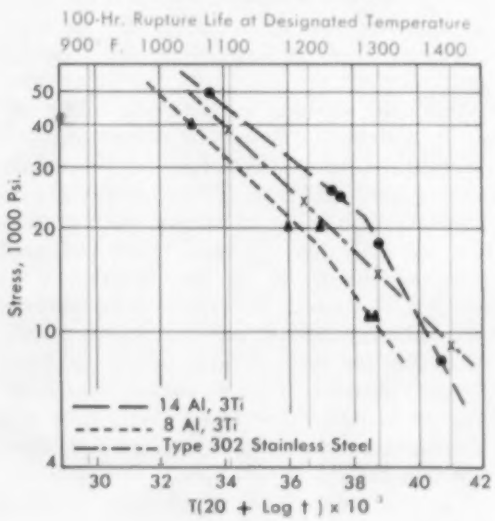
Molybdenum and vanadium, two elements widely used in other high-temperature alloys, are less satisfactory as hot strengtheners for iron-aluminum alloys. Molybdenum also reduces oxidation resistance. Recent improvements in the room-temperature ductility of the 14% aluminum-base alloy will allow greater alloying additions of hot strengthening elements such as titanium without producing brittleness and increasing the creep-rupture life over that of the alloy with 3% titanium.

A unique feature of iron-aluminum alloys is their wide applicability. For heat resistance their potential uses vary from turbo machines to furnace hardware. The cheapness and availability of aluminum are further incentives for employment of these alloys. Although the heat resistant properties have been emphasized in this report, the unusual magnetic characteristics of iron-aluminum alloys are equally attractive. In this field also, increased ductility and ease of fabrication are important factors.

Furnace hardware provides an especially fruitful area of exploitation of iron-aluminum alloys. Field test data indicate that iron-aluminum alloys can be substituted for many costly and strategic austenitic stainless steels. Samples which have been placed in carburizing and carbo-nitriding furnaces for periods up to 500 hr. exhibited excellent corrosion resistance. The possibilities of iron-aluminum wires as resistance heating elements were noted by Sykes and Bampfylde.

Although it is difficult to evaluate the resistance of iron-aluminum alloys to chemical corrosion without extensive field testing, sufficient data exist to indicate that it may be somewhat below that of the austenitic steels. However, in their resistance to hot sulphurous gas attack they are known to be superior to stainless steels.

Fig. 5 – Stress-Rupture Properties of Two Fe-Al-Ti Alloys



*"A Time-Temperature Relationship for Rupture and Creep Stresses", by F. R. Larson and James Miller, *Transactions* of the American Society of Mechanical Engineers, Vol. 74, 1952, p. 765 to 771.

Book Review

Reference and Bibliography on Nickel Steels and Irons

*Reviewed by DAVID S. WOOD**

NICKEL IN IRON AND STEEL, by A. M. Hall, Alloys of Iron Research Monograph Series, John Wiley & Sons, Inc., New York, 595 p., 1954. $10.

THE INDIVIDUAL metallurgist or engineer is constantly faced with problems for which he needs detailed, quantitative information concerning specific properties of metals. The required data are not often to be found in the standard texts since the latter usually include only sufficient data to illustrate general principles. The A.S.M. Metals Handbook and other handbooks are more likely to provide the answer, but even these refer to a relatively small fraction of the technical literature pertaining to any specific problem. They may provide a partial answer and sometimes no answer at all. Of course the required information or data may not exist, but there is always the feeling that it is contained in some paper published in a technical journal. The prospect of an exhaustive literature search with the possibility of negative results is disconcerting at best, and such a search is usually prohibitively time-consuming. In practice the desired data may be obtained experimentally in preference to making the literature search. For this reason many facts concerning metals are repeatedly "discovered" by different investigators.

The Engineering Foundation through its Committee on Iron Alloys set for itself the monumental task of rectifying this state of affairs so far as the field of iron and its alloys is concerned. The monograph, "Nickel in Iron and Steel," by A. M. Hall, is the 13th such volume to appear in the series published under the auspices of the Iron Alloys Committee under the editorial direction of Frank T. Sisco. The stated purpose of these monographs is "to provide metallurgists and engineers with concise but comprehensive summaries of available data, as reported in the technical literature of the world, on the effect of selected metals on carbon steels and on simple and complex alloy steels and cast irons". A. M. Hall has certainly carried out this objective in the present volume.

"Nickel in Iron and Steel" is essentially limited in scope to the effects of nickel in low-alloy steels and in cast irons. The interesting field of high-nickel alloys of iron is covered by a previous monograph of the same series "Alloys of Iron and Nickel, Vol. I, Special-Purpose Alloys" by J. S. Marsh. However, the present volume does include an introductory chapter on nickel minerals, the occurrence of nickel ores and refining. All phases of the subject are covered from melting through miscellaneous fabrication methods plus a fairly complete discussion of mechanical properties and how they are affected by temperature. In the chapter devoted to heat treatment, the kinetics of austenite decomposition and hardenability are particularly well covered.

A reference work such as "Nickel in Iron and Steel" is anything but light reading and few metallurgists or engineers will care to peruse it completely or systematically. However, this is due to the basic nature of the work and in no way detracts from its value or reflects upon the author's skill in presentation. The material, which has been abstracted from nearly 800 references, is well correlated and logically arranged. The author introduces each topic with a brief general discussion of principles that sets the stage for the detailed exposition. A sound knowledge of physical metallurgy is required of the reader for a a full understanding and appreciation of the book. However, many who are not specialists in metallurgy will find that this book is a valuable source of detailed data, useful for the choice of nickel steels and cast irons in design.

There is one basic difficulty involved in a book concerned with such a specialized field as the effects of a single alloying element in iron and steel. Many important properties of iron and steel depend upon the simultaneous influences of several alloying elements, and it is desirable to compare the effects of various alloying elements with one another. The author has succeeded in striking a good balance between the conflicting requirements of keeping the book within its bounds and at the same time indicating to some degree the relationships and comparisons between nickel and the other important alloying elements in iron and steel.

*Professor, Department of Mechanical Engineering, California Institute of Technology, Pasadena.

Genetic Effects of Atom Bombs*

In the ordinary atomic [uranium or plutonium]† bomb, about 2 lb. of radioactive materials are produced for each 20,000 tons TNT equivalent, consisting of some 90 isotopes varying widely in life. The mixture as a whole decreases one-tenth for every sevenfold increase in age; thus the radioactivity 7 hr. after the explosion has decreased to one-tenth its radioactivity at 1 hr., at 49 hr. (2 days) to one-hundredth, and so on.

"Fall-out" of this material from the air depends on various conditions. Particles from a bomb fired in the air are very tiny and slow in settling; most of the radioactivity is expended in the air, but the area of detectable dissemination of the balance usually extends to the ends of the earth. A bomb fired on or near the surface of the earth [sweeps up enormous numbers of coarse particles]. Many of the radioactive isotopes are nonvolatile, condense on these solid materials, and fall out within short distances. Again, firing over water should create very different conditions.

[As to distribution of fall-out] one can say that the fraction precipitated near the test site usually is large for surface shots and relatively small for aerial shots. The spread is also determined by the winds and rainfall. [In any event] the area is large and constitutes a real problem for civilian defense.

What are the effects on living systems? Radiation distintegrates molecules and thus changes these living systems. It is known that radiation dosages in the levels of 400 Roentgen units (400 r) kill half the individuals exposed. As of Jan. 1, 1955, the average contamination of the U.S. corresponded to a dosage *rate* of 0.001 r per yr.‡, it having decreased by natural decay to that value on that date from an average of 0.015 r for the entire year 1954 [resulting from the Pacific tests]. If all the dosage from all atomic tests be added together, the total dosage for people in the U.S. averages considerably less than 0.100 r, or 1/6000 the lethal dose [about half the annual dosage of Colorado residents each year from natural causes].

Strontium-90 – Among the fission products, strontium-90 deserves special attention. About 2.5% of the fission acts [fissioning atoms] yield this. Its average lifetime of 30 years means that it will be with us for a generation. It is chemically so similar to calcium that it is incorporated in the bone structure and is a potential source of bone tumor. Careful assays of the earth's surface and of living matter indicate that there is now about 0.001 curie of Sr^{90} per sq.mi. in the top soil in the U. S. Evidence is that the whole earth is contaminated at a somewhat lower level, and the total corresponds to the amount of Sr^{90} produced by atomic bombs totalling 1 megaton total fission [equivalent to 50 "ordinary" atomic bombs of 20,000 tons TNT equivalent].

Why is not the Sr^{90} level higher, since much more has been produced than is found scattered around the world? This is because the surface shots of the large bombs fired at the Pacific testing grounds precipitated a large fraction of their radioactivity into the depths of the ocean, and perhaps also because a considerable amount of Sr^{90} is still residing in the atmosphere and being slowly precipitated. This radioactive strontium is responsible for about 2.2 disintegrations per min. per gram of calcium in living organisms, a figure which is to be compared with the natural radioactivity of carbon in the body (15 disintegrations per min. per g.) and potassium (2000 disintegrations per min. per g.).

Experience with radium – which constitutes approximately the same hazard in drinking water as does Sr^{90} in food stuffs – indicates that the first effects, namely the observable increase in bone tumors, would appear at levels about 10,000 times greater than the present. Strontium-90 constitutes no genetic hazard so far as we know.

*Verbatim extracts from address on "Radioactive Fallout" by A.E.C. Commissioner Willard F. Libby at University of Chicago, June 3, 1955.

†Words in brackets represent interpolations by the editor.

‡While Dr. Libby was not specific on this point, he uses the word "contamination", hence one infers that the natural or background radioactivity to be described later and amounting to about 0.150 r. per year for residents of Denver, Colo., has been increased as of Jan. 1, 1955 by atomic bomb explosions by 0.001 r per year.

Background Radiation – At this point I should speak about the facts of life as far as natural radioactivities are concerned. Everyone in the whole world has always been exposed to these "background" radiations. The human body has enough radioactive carbon in it so that it receives 0.0015 r per year of radiation from this source. In addition the radioactive potassium isotope gives the human body much more, namely 0.019 r per year. [Altogether each person is receiving and has received] 0.020 r per year of natural inherent radiation, generated within itself.

The principal sources of natural dosages, however, are the cosmic rays and the radioactivities in the earth itself due to the potassium, thorium and uranium minerals present in the rocks and soil. Cosmic rays are of less intensity at sea level than at higher elevations. At 5000 ft. altitude [as Denver, Colo.] the dosages from cosmic rays are about 0.050 r per year. Ordinary granite rock produces radiation dosages of 0.100 r per year. People living on the earth at 5000 ft. elevation in granitic areas [like the inhabitants of Denver – considered a healthy spot] receive 0.150 to 0.170 r per year from cosmic and terrestrial radiations. The seafarer has the lowest natural dosage rate of about 0.055 r per year. Those living near sea level over sedimentary rocks receive about 0.115 r per year.* Whatever the genetic effects of such radiation may be, they have been in application since the beginning of human time.

It is quite clear that natural radioactivities constitute "hazards" much greater than the fall-out from the bomb tests to date, and that if the genetic damages from the tests are real we have always had them in much larger measure from nature. It also means that in case of a full-scale atomic war, where the fall-out might increase a thousand-fold, there will be additional hazards due to the fall-out.

Genetic Considerations† – The ability of radiation to change the genes, the heredity material of mankind, has been publicly discussed with widely contrasting opinions. From extensive researches supported by the A. E. C. in numerous universities and institutes it has been found that irradiation of animals and plants adds to the number of more-or-less detrimental mutations.

Mutations occur spontaneously at all times, most of them acting unfavorably on development, growth or well-being. Spontaneously mutated genes have accumulated in large numbers in all humans, and account for the 1% of abnormal individuals – most abnormalities being of very slight degree but some more serious. A considerable number of the "spontaneous" mutations of man are probably caused by natural background irradiation.

Irradiation from fall-out and from peaceful uses of nuclear energy will result in additional mutations in human genes whose number cannot now be estimated accurately. Among the annual 4,000,000 American births, from 100 to several thousand may carry a mutated gene as a result of irradiation by existing fall-out. Only slowly, over hundreds of years, will the majority of these radiation-induced genes become apparent, in a few individuals at a time, usually by causing a less-than-normal development or functioning. These cannot be identified among the 40,000 defectives occurring spontaneously each year, and will not change the number measurably.‡

No significant change in the percentage of malformed children has yet been observed in those born of parents exposed to the atomic bombs in Hiroshima and Nagasaki.

These conclusions apply only to the forseeable future. The genetic effects of a nuclear war would be one of the many catastrophic consequences of such a disaster.

*A luminous dial wristwatch will expose the central portions of the body to 0.040 r per year. An X-ray of the abdomen, front to back, involves 1.5 r for each photograph. Workers in the A.E.C. plants are allowed a maximum exposure of 15 r per year.

†The remainder is quoted from a unanimous report of the A.E.C. Advisory Committee for Biology and Medicine.

‡Editor's Query – It seems inherent in the above discussion that *all* additional mutations from increased radioactive levels will be damaging, yet it also seems to be an accepted theory that mutations are necessary for progress, in the sense that they cause some fitter-than-average personalities to appear – in other words, that mutations brought us up out of the primordial slime. Is it not possible that along with a few "less-than-normal" humans, a Lincoln, a Newton or a Beethoven might also be produced?

Monel, 1905 to 1955

*By W. A. MUDGE**

Monel nickel-copper alloy was first produced 50 years ago and its continued development parallels the progress in metals engineering. (A2, Ni)

THE International Nickel Co. was a small organization in 1905. It had been formed three years before by consolidation of the Canadian Copper Co., at Copper Cliff, Ont., Canada, which had extensive ownership in the recently discovered nickel-copper ore bodies near Sudbury, and of the Orford Copper Co. in New Jersey, which was using its patented "tops and bottoms" process (1)† for refining nickel from this ore. Robert C. Stanley‡ was assistant general manager and D. H. Browne was metallurgical engineer at Copper Cliff. In this year, Inco's production of nickel from Canadian ores had exceeded that from silicate ores of New Caledonia in the South Pacific. This was a leadership which Canada has never lost.

Dr. Browne believed that oxidation of the nickel-copper matte used for the production of nickel and reduction of its oxide with charcoal, without previous separation of the two metallic sulphides, would provide a molten alloy of nickel and copper to which zinc could be added. In this way he could produce german silver more economically than by the conventional melting of its three component metals. Stanley perfected this process in 1905. Instead of adding zinc, he deoxidized the molten nickel-copper with magnesium, which was common practice at the time for malleable nickel. He cast the product into an ingot, and forged it to bar stock. Thus, fifty years ago a new wrought alloy was born (2). The designation Monel* applied to it was adopted in honor of Ambrose Monell, who, at the time of this discovery and early development, was president of Inco.

Stanley and his associates observed that the new alloy was silvery white, brighter than nickel, stronger than mild steel and more resistant than bronze to sulphuric acid and salt water. This was unique for anything metallic at that time. They engaged Prof. William Campbell of Columbia University to determine and evaluate these and other properties more accurately and Prof. Hal T. Beans to make a comprehensive survey of the nickel literature. John F. Thompson was then assistant in metallurgy at Columbia, and aided Professor Campbell in the initial program.

The results were so encouraging that Inco engaged Dr. Thompson† to start the first technical organization in the company for research, control of production, and cooperation with commercial developments.

Initial development was based largely on observation and imagination. The new alloy resisted sulphuric acid so well that it could not be pickled without the addition of ferric chloride or nitric acid. A Monel shaft in a pump at the company's plant handling salt water from New York harbor did not corrode. The alloy did not tarnish as

*Director, Technical Service Section, Development and Research Div., The International Nickel Co., Inc., New York.

†See list of references on p. 236.

‡Mr. Stanley became general superintendent of Inco in 1912, vice-president in charge of operations in 1918, president in 1922, and was chairman of the board of directors at his death in 1951. A biographical appreciation appeared in *Metal Progress* in November 1944 on the occasion of his receipt of the Medal for the Advancement of Research.

*EDITOR'S FOOTNOTE – The author requests that it be stated that Monel is the registered trade mark of the International Nickel Co., Inc., applied to nickel-copper alloys produced and marketed by it. Likewise that "K" Monel, "H" Monel, "S" Monel, "R" Monel, "KR" Monel, "326" Monel, "Duranickel", "Permanickel", "Ni-Span-C", Incoloy, Inconel "X" and Ni-O-Nel mentioned later in this article are also registered trade marks of the International Nickel Co., Inc.

†Dr. Thompson became assistant to the president in 1928 after five years as manager of operations, vice-president in 1932, president in 1949 and chairman in 1951.

readily as copper in the metropolitan atmosphere, and hot steam neither corroded it nor decreased its strength. These facts suggested initial uses as pickling equipment for the steel industry, rods and shafts for marine pumps, valves, turbine blading, in the form of castings for oil stills, and as roofs for buildings.

Before finished products could be secured, ingots had to be processed to rod, bar and sheet. The company had neither hot working nor cold working equipment. So, arrangements were made to produce sheet at the Vandergrift (Pa.) Works of the American Sheet and Tin Plate Co., and later at the West Penn Steel Co. at Brackenridge, Pa.; rod at the Harrison (N.J.) Works of the Crucible Steel Co.; and plate at the Central Iron and Steel Co., Harrisburg, Pa. Approximately 500,000 lb. was sold in 1907 and a year later the first large order, 264,000 lb. of sheet for the roof of the New Pennsylvania Railroad Station in New York City was received. The installation was made in 1909 and is still giving trouble-free service. Publicity stimulated other demands and two years later the technical literature included 23 references to applications of the alloy. Prominent among these were golf clubs, propellers for the battleships U.S.S. North Dakota and U.S.S. Florida, and Monel metal turbine nozzles and porthole frames for ships in the Japanese, Italian and Argentine navies.

With this superior corrosion resistant material, the chemical and petroleum industries were able to improve some of their operations, electricity could be generated at higher temperatures, and marine equipment could be relied upon to function for extended periods without maintenance and repair. This last was of considerable importance to the United States and British navies during World War I. At the end of the war, the U. S. Navy's interest in Monel alloys had become as great as it had been in nickel steels some 20 years earlier.

Although increases in personnel for production, research and sales had been made before and during the war, it was clearly evident by 1920 that these were insufficient. Shipments had decreased and new uses for the Monel alloys had to be found. A new refinery and rolling mill were built in Huntington, W. Va., and operations were begun on May 25, 1922, with A. S. Shoffstall as general manager and H. M. Brown as assistant general manager. Shoffstall had been responsible for the production of sheet at Vandergrift and West Penn, and Brown was in charge of the construction of the mill. Also, the foundry at Bayonne, N. J., was enlarged to produce centrifugal castings as well as sand castings.

Sales personnel naturally increased. Under J. F. McNamara's direction, specialists were also employed to work with customers in the various industries.

Furthermore, a research fellowship was established at the Mellon Institute in Pittsburgh. More important, a development and research department of the company was created with A. J. Wadhams as manager and Paul D. Merica† as assistant manager and director of research. Wadhams had been general manager of the Orford Works for some time and Merica had joined Inco recently after a brilliant career at the National Bureau of Standards, Washington, D. C. The technical staff at Huntington was increased; a new research laboratory was built at Bayonne, with O. B. J. Fraser‡ as manager; technical information centers were established in England and in four European countries; and a technical service section of the division was organized, with R. J. McKay in charge, to secure and disseminate information on physical and mechanical properties, resistance to corrosion, and fabrication of Monel and other Inco alloys.

Sales, increasing three-fold in the 1920 decade, justified these efforts, and production facilities at Huntington were increased accordingly. Forty men were engaged in research on the Monel alloys. Their corrosion resistance was responsible for more than half the 800 recorded uses.

Corrosion Resistance

In 1933 inspection of some nickel steel plates from a ship's hull showed that they had been corroded less by salt water than carbon steel plates (3). The facts did not explain how much the nickel steel had benefited from galvanic protection by the mild steel with which it was in contact. To answer this question, F. L. LaQue immersed specimens of many steels in sea water at the Ethyl-Dow Works, Kure Beach, N. C., under conditions where galvanic action could be controlled and the effect of the growth of marine organisms could also be studied.

This site was found to be ideal for study of other metals, alloys and many nonmetallic materials and protective coatings. In 1935, LaQue

†Assistant to the president, 1932; vice-president, 1936; executive vice-president, 1949; president, 1952. A biographical appreciation was printed in *Metal Progress* for May 1936.

‡Mr. Fraser's biography was a feature article in *Metal Progress* for July 1955.

founded the Inco Marine Testing Station at Kure Beach for research on corrosion under immersed and atmospheric conditions (4). Specimens of Monel and other high-nickel alloys, stainless steels, aluminum alloys, copper-base alloys and steels were studied first. The value of the data obtained led to the expansion of the facilities and finally to the construction of a new underwater station at nearby Harbor Island. This and the atmospheric station at Kure Beach are the largest of their kind in the world. To date, approximately 5000 test projects have been completed with 500 materials. The results have contributed significantly to proper use of materials in marine engineering as well as to fundamental knowledge of corrosion processes and how to avoid their damaging effects.

Although financed and managed by Inco, the station is an outstanding example of cooperative research. Specimens have been submitted by most of the major producers of ferrous and nonferrous metals and alloys. Data are exchanged freely with the participating organizations and their representatives visit the station periodically for inspection of specimens and comparison of results.

Paralleling the work at Kure Beach, the behavior of the Monel alloys and other metallic materials in many corrosive mediums was studied. The difficulty of duplicating plant operating conditions in a laboratory test with sufficient accuracy and regularity to predict economical commercial performance led to the development and successful use of the spool-type specimen holder (5, 6), now a standard of the American Society for Testing Materials. In 25 years 10,500 of these holders, with 210,000 specimens of 170 metals and alloys have been exposed in practically all of the corrosive environments encountered in industry.

Important industrial applications of Monel alloys have resulted from the studies at these stations in North Carolina, ranging all the way from naval ordnance to the chemical industry, and especially important ones in all branches of petroleum production and refining.

Age Hardening

As early as 1908, when Inco's original Monel alloy was under consideration for turbine blading, Dr. Thompson had added to it varying quantities of chromium, manganese, aluminum, iron, molybdenum, tungsten, titanium and other metals, to give increased strength (7). Dr. Merica continued the work 11 years later and patented a nickel-copper alloy containing up to 17% aluminum (8).

Technical control of the production of this new alloy at the Huntington Works was under the author's direction. Early in 1924 he had one of those fortunate accidents. Microscopic examination of an unusually hard specimen disclosed a eutectic structure similar to that in oxidized copper. This was something new. Possibly the alloy was not the solid solution that all had believed it to be. A duplicate specimen was quenched from 1600° F. and had a hardness of Brinell 150. After aging overnight at 1000° F., its hardness was Brinell 275.

Thus, the first age hardening, wrought nickel alloy was discovered (9). But microscopic examination of this hardened specimen did not disclose the eutectic structure! Within the hour, the "eutectic" in the first specimen was found to

Table I — Properties of Monel Alloys

Trademark	Available Forms*	Chemical Composition (Maximim Unless Specified Otherwise)							Yield,‡ 1000 Psi.	Tensile, 1000 Psi.	Elongation, % in 2 In.
		Ni	Cu	Mn	Fe	Si	S	C			
Wrought Alloys											
Monel	A,B,C,D,E,F	63-70	bal.	2.0	2.5	0.50	0.024	0.30	25-165	70-170	50-2
"R" Monel	A,B,C	63-70	bal.	2.0	2.5	0.50	0.025-0.060	0.30	25-155	70-160	50-2
"K" Monel†	A,B,C,D,E,F	63-70	bal.	1.50	2.0	1.0	0.01	0.25	40-190	90-210	45-2
"KR" Monel†	A,B,C	63-70	bal.	1.50	2.0	1.0	0.01	0.20-0.30	40-180	90-200	45-2
"326" Monel	A,B,C,D,E	55-60	bal.	2.25	2.5	0.75	0.024	0.30	25-155	75-160	50-2
Cast Alloys											
Monel	G	62-68	bal.	0.5-1.5	2.5	1.0 -2.24		0.35	32-40	65-90	45-25
"H" Monel	G	62-68	bal.	0.5-1.5	3.0	2.25-3.49		0.30	70-90	90-115	3-1
"S" Monel	G	62-68	bal.	0.5-1.5	3.5	3.5 -5.0		0.25	80-115	110-145	4-1

*A—Rods and bars; B—Forgings; C—Wire; D—Sheet; E—Strip; F—Tubing; G—Castings.

†Age hardenable, with 2 to 4% Al and 0.25 to 1.0% Ti. ‡0.2% offset.

be an accidental arrangement of tiny particles of dust from the etching solution!

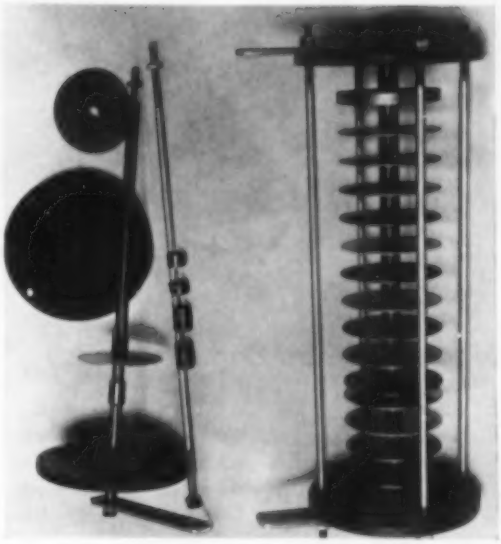
This new "K" Monel age hardening nickel-copper alloy has the same versatile fabricating advantages as duralumin; it can be fabricated in the soft condition and subsequently hardened to strength levels comparable to those of the alloyed steels. Uses to date have totaled 37,500,000 lb. Its chemical composition was modified a few years later by the substitution of titanium for a part of the aluminum in the alloy (10). This improvement remains in effect today.

Today, 16 elements are known to confer age hardening characteristics to nickel. Aluminum, titanium and silicon are most important and magnesium, molybdenum, tungsten and beryllium are used to a lesser extent.

The metallurgy of the age hardening Monel alloys led also to the Duranickel, Permanickel, Ni-Span-C, Inconel "X" and Nimonic* alloys. There are also Waspaloy, Jetaloy 1570, S-816, N-155, M-252 and similar alloys produced by other manufacturers for this purpose. Each of these relies upon nickel and one or more hardening elements for its age hardening characteristics.

"H" and "S" Monel nickel-copper alloys, made with 3 and 4% silicon respectively, were also found to be age hardening. Then came the "R" and "KR" Monel free-machining alloys, another Monel alloy for hot-water tanks, three for welding wires; and "326" Monel alloy for pickling equipment and nonmagnetic applications. Their chemical compositions and ranges of mechanical properties are given in Table I. During the past 50 years 896,228,000 lb. has been delivered to industry – a total which would have been greater if defense and stockpiling had not diverted nickel from many industrial uses.

Of course the original Monel alloy was not the first metallic engineering material. Alloy steels were made about 1830; nickel silver had been used since 1835; aluminum bronze since 1861; constantan and manganin since 1887; admiralty brass since 1890; and corrosion resisting copper-bearing steels were available in 1900. But Inco's scientific development constituted the first search for an accurate understanding of quality in alloys by control of their composition, production, fabrication, and heat treatment, and thereby established the underlying principles for building other successful alloys. The various alloys of nickel represent the first steps in the current practice of tailoring metals to meet specialized requirements. Appreciation for the necessary care in the design and use of equipment to take advantage of the properties of alloys has been a most profitable result.



Spool-Type Specimen Holder Developed for Corrosion Tests

Monel alloys and cupronickels are useful for resistance to corrosion under reducing conditions but not under oxidizing conditions nor at temperatures above 1000° F. The ferritic high-chromium alloys discovered by F. M. Becket in 1914 and the chromium-nickel austenitic stainless steels (11) exhibited by Krupp that same year satisfied requirements for oxidizing conditions except for special and unusual services.

There are many reasons why uses of the Monel alloys will increase in the future as they have in the past. We in the Inco organization believe today, as we did 50 years ago, that "the development of new materials of construction requires sound ore reserves, large and efficient production, skilled and experienced distribution supported by ample research and technical services" (12).

The author is happy and proud to have had a part in an important development. Its successes are the result of the accomplishments of many workers within and outside the Inco organization. He is particularly grateful to Dr. Thompson for his assistance; without this, the story could not have been written.

*Registered trade mark. Nimonic was developed by the Monel Nickel Co., the English subsidiary of the International Nickel Co., and is made both in England and in Inco's Huntington works in West Virginia.



Correspondence . . .

Measuring Case Depth

NORTHAMPTON, ENGLAND

Since various articles and letters have recently appeared in *Metal Progress* on the measurement of case depth (and it is undoubtedly an important problem) we would like to record the method used with entire satisfaction by British Timken Ltd. Chemical analysis of successive layers is obviously unsuitable for shop control. Hardness-depth curves, made in various ways, give indications which are not too closely correlated with carbon content – a matter which is closely specified in our work. Fracture and acid etch do not disclose unsatisfactory gas carburizing operations on the low-alloy steels which we use in large tonnage.

When carburizing components from a steel approximating S.A.E. 4620 and checking case depth to the 0.80% carbon level, we proceed as follows: A section is cut or broken from the carburized test piece and ground on one face. It is then austenitized at 1470° F. and quenched for 30 sec. at 375° F. in a small salt bath, and then quenched in water. (375° F. is Ms temperature for 0.80% C in this 4620 steel.) The specimen is lightly ground, polished, etched in 2% nital and examined microscopically, with the clearly defined result as shown in the photomicrograph. If the piece is cut or heavily ground *after* quenching, the light zone will be indistinguishable from the remainder.

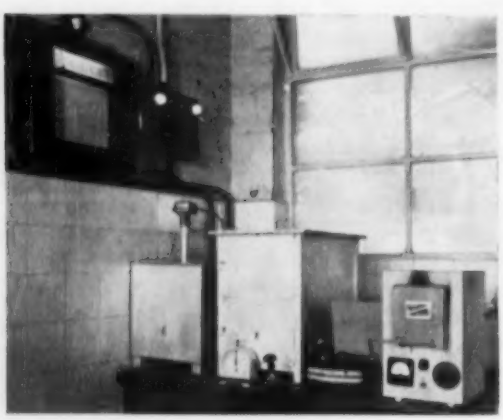
This scheme was presented and discussed in some detail by E. S. Rowland and S. R. Lyle of Timken Roller Bearing Co. in *Metal Progress* for May 1945 and *Transactions* of the American Society for Metals for 1946 (Vo. 37, p. 27). It depends upon the sharp demarcation between the white, freshly quenched martensite and the lower-carbon steel which has transformed isothermally. We use A. E. Nehrenberg's formula for calculating Ms in °F.:

$$Ms = 930 - 540 \times \%C - 60 \times \%Mn - 40 \times \%Cr - 30 \times \%Ni - 20 \times \%Si - 20 \times \%Mo$$

We have had satisfactory checks between this method and chemical analysis. Austenitizing and isothermal quenching temperatures may vary ± 10° without making any observable difference in the results.

Lest anyone should think the required apparatus is elaborate and costly, ours is shown in the photograph at left. The salt bath and aus-

(Continued on p. 138)



Home-Made Equipment Includes Austenitizing Furnace in Center and Isothermal Quench (Salt Bath) at Left

Carburized Case (White) at Left; Beginning of Core at Right. Demarcation Line: 0.80% C in S. A. E. 4620



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Boron . . Ferroboron (in minimum 10.00% and 17.50% Boron grades), Manganese-Boron, Nickel-Boron and Boron Carbide.

Calcium . . Calcium-Silicon, Calcium-Manganese-Silicon, and Calcium Metal.

Chromium . . "Simplex" Low-Carbon Ferrochrome (as low as 0.010% maximum Carbon), Low-Carbon Ferrochrome (from 0.02% to 2.00% maximum Carbon), Nitrogen-Bearing Low-Carbon Ferrochrome, High-Carbon Ferrochrome, Exothermic Ferrochrome, Exothermic Silicon-Chrome, "EM" Ferrochrome-Silicon, "EM" Ferrosilicon-Chrome, "SM" Ferrochrome, Foundry Ferrochrome, Foundry Ferrosilicon-Chrome, Electrolytic Chromium Metal, and other Chromium Alloys.

Columbium . . Ferrocolumbium and Ferrotantalum-Columbium.

Manganese . . Standard Ferromanganese, Low- and Medium-Carbon Ferromanganese, Low-Iron Ferromanganese, "Mansiloy" Alloy, Electrolytic Manganese Metal, and other Manganese Alloys.

Silicomanganese . . In maximum 1.50%, 2.00%, and 3.00% carbon grades.

Silicon . . Ferrosilicon in all grades, including both regular and low-aluminum material, Silicon Metal, "SMZ" Alloy, Magnesium Ferrosilicon, and other Silicon Alloys.

Titanium . . Low-Carbon Ferrotitanium, Silicon-Titanium, and Manganese-Nickel-Titanium.

Tungsten . . Ferrotungsten, Tungsten Powder, Calcium Tungstate, and Calcium Tungstate Nuggets.

Vanadium . . Ferrovanadium in all grades, Vanadium Oxide (Fused), Sodium Polyvanadate (Red Cake), and Ammonium Metavanadate.

Zirconium . . 12 to 15% and 35 to 40% Zirconium Alloys, and Nickel-Zirconium.

"EM" Briquets . . Silicon, Silicomanganese, Ferromanganese, Chromium, and Zirconium Briquets.

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tenitizing furnaces at left and center respectively were made on our own premises. The major cost involved therefore was for pyrometric control, which for the quenching bath is of the potentiometric type.

H. C. THOMAS
Metallurgist,
British Timken, Ltd.

JACKSON, MICH.

It seems to me that the standardization of methods for measuring case depth, mentioned by several recent correspondents in *Metal Progress*, has already been done by the Society of Automotive Engineers.

The S.A.E. Handbook for 1955 carries the information on p. 173. This information was developed and recently revised by the Society's Iron and Steel Technical Committee composed of metallurgists in automotive, farm tractor, aircraft and parts manufacturers plants and should represent the latest thinking in shop, laboratory and referee methods of measuring case depth.

Very briefly, the "S.A.E. Recommended Practice – Methods of Measuring Case Depth" distinguishes between total case and effective case on carburized or carbo-nitrided parts. Total case is the distance from surface to core – that is, to where the carbon content has been increased no more than 0.04 – and is best measured by chemical analysis of turnings 0.002 to 0.010 in. thick. Alternatively, an annealed sample may be sectioned, polished and etched for micro-examination; "for total case depth measurement, read the depth of carbon enrichment" (to quote the Recommended Practice).

Effective case depth is the depth to C-50 hardness in a quenched specimen. Recommended procedures are to determine hardness-depth relations on a section normal to the surface, a taper ground or a step ground surface. Visually, effective case depth is the darkened zone in a specimen fractured or cut normal to the surface, etched in strong nital, and measured at 20 magnifications with a Brinell glass. In hardened specimens prepared for micro-examination, depth should be read at 100 diameters "to metallographic structures which have been shown to be equivalent to Rockwell C-30".

L. E. WEBB
Chief Metallurgist
Clark Equipment Co.

Cast Bolts for Pipe Joints

DETROIT

I was interested to read in *Metal Progress* for May 1955 the article by C. K. Donoho on "Cast Bolts for Pipe Joints" as made by the American Cast Iron Pipe Co. under U. S. Patent No. 2,220,792.

This method of making malleable iron in a short time was patented by the writer under patent No. 1,591,598, dated July 6, 1926, and the process was in production operation at Harrison Radiator Co. for one year sometime between 1923 and 1925 for making radiator inlet and outlet castings. Annealing time for these castings was about 2 hr.

It would seem that the only detail on which patent No. 2,220,792 could have been granted would be on the addition of 0.6 to 1.0% copper, as can be seen by a comparison of the composition ranges in the two patents.

Under normal patent department procedure this older patent would have been cited as prior art anticipating the application involving the addition of copper.

A. L. BOEGEHOLD
Assistant to General Manager
General Motors Research Labs.

BIRMINGHAM, ALA.

We agree that Boegehold's 1926 patent No. 1,591,598 is the earliest disclosure we have seen regarding the metallurgical principle of chilling in a metal mold to produce white iron and then annealing to produce malleable. This patent was cited against us by the Patent Office. (Incidentally, there is also a Ford Motor Co. patent, later than Boegehold's covering essentially the same idea.) Our patent No. 2,220,792 was finally granted in 1940 after we limited the claims to a very specific product and to the copper-bearing composition.

I was possibly over-zealous in talking about "a novel metallurgical process", but I was really thinking of it as a method of producing pipe bolts, which was novel in the degree of mechanization and quality control. Also, we consider as novel the combination of the metal-molded bolt with the shell-molded nut to take advantage of the virtues of both processes for differing requirements.

C. K. DONOHO
Chief Metallurgist
American Cast Iron Pipe Co.

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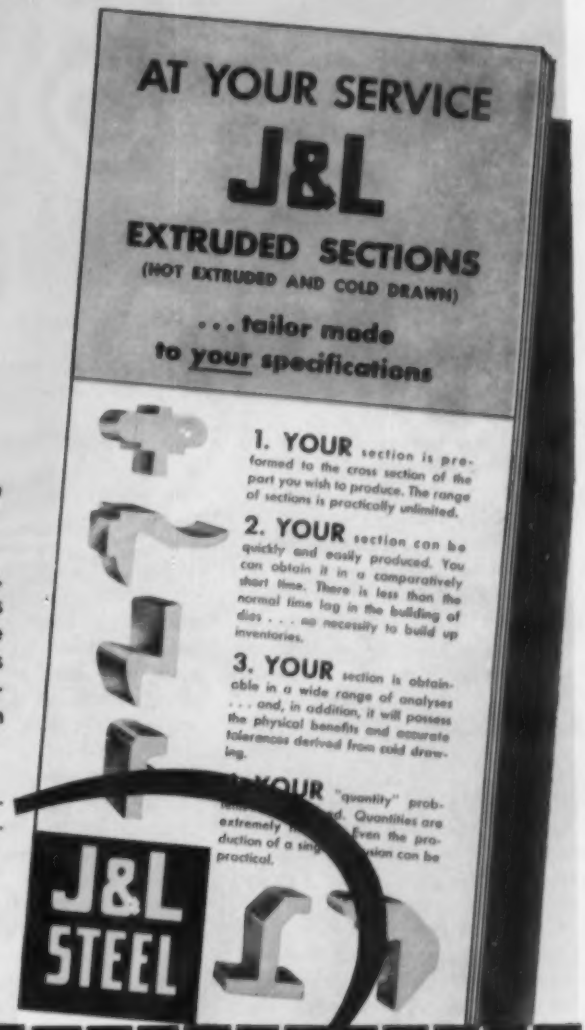
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Personal Mention



J. Walter Gulliksen

J. WALTER GULLIKSEN, general manager of the Waterbury Mfg. Co. Div. of Chase Brass and Copper Co., Inc., a subsidiary of Kennecott Copper Corp., has been elected vice-president of the Waterbury Mfg. Co. Div. of Chase Brass.

Before coming to Chase in 1954, Mr. Gulliksen was connected with Worcester Pressed Steel Co., joining that organization in 1942 as assistant to the general manager. In 1946 he was made general superintendent and soon thereafter was appointed to the board of directors and later promoted to factory manager. Prior to 1942, Mr. Gulliksen had spent 15 years in various capacities with the Aluminum Co. of America, Edgewater, N. J., including two years with the Aluminum Index Co. as factory superintendent.

A native of New York City, Mr. Gulliksen graduated from Stevens Institute of Technology with a degree in mechanical engineering. He has also completed post-graduate work in commercial law and salesmanship at New York University; industrial personnel management at Rutgers; and metallurgy at Worcester Polytechnic Institute. Mr. Gulliksen is nationally known for his work on the deep drawing of titanium, and has written many technical articles. He is a past chairman of the Worcester Chapter of A.S.M., and has been active in various other technical societies.



Raymond K. Bowden

Raymond K. Bowden, director of quality surveys for the United States Steel Corp., Pittsburgh, was one of the recipients of professional engineer degrees from Ohio State University in June. The professional degrees, sometimes termed "earned honoraries," are conferred by the University each June "in recognition of engineering ability and accomplishments of a high order." Each candidate must be an alumnus of Ohio State, must have at least eight years' experience in active engineering practice, and must submit a thesis based on his experience and accomplishments. Mr. Bowden, who received the degree of metallurgical engineer, earned his bachelor's degree in mining engineering from Ohio State in 1920. His outstanding career in the steel industry covers a 38-year period, beginning in 1917 when he took a two-year time-out from college to work as assistant chief inspector for the Central Steel Co., Massillon, Ohio. In 1923 he rejoined that company and worked for Central and its successors – Central Alloy Steel Corp. and Republic Steel Corp. – until 1930. Since that time he has been associated with Illinois Steel Corp., and its successors, Carnegie-Illinois and U.S. Steel.

George H. Hatfield, formerly district manager of Wheelco Instruments, Chicago, is now with Esch and Associates, Inc., Houston, Tex.

James P. McNally has been appointed sales manager of Bart Mfg. Corp., Belleville, N. J. Mr. McNally was formerly metallurgical technical adviser with the same company and prior to that time was employed by the Carrier Corp., Syracuse, N. Y.

Ronald W. Price has been named district manager for abrasive sales in all New England states for the Norton Co., Worcester, Mass. Mr. Price has been connected with the company since 1926, and prior to his recent appointment he was district manager for the state of Connecticut.

David L. Cooke has been transferred from the Detroit sales office of the Rotary Electric Steel Co. to the Newark sales office.

Kenneth Bock has been appointed full-time representative of the LaSalle Steel Co., Chicago, in the Los Angeles-Southern California area. Joining the company's production department several years ago, Mr. Bock has served as a Milwaukee, Wis. district representative and more recently as manager of distributor sales, based in the company's Hammond, Ind. office.

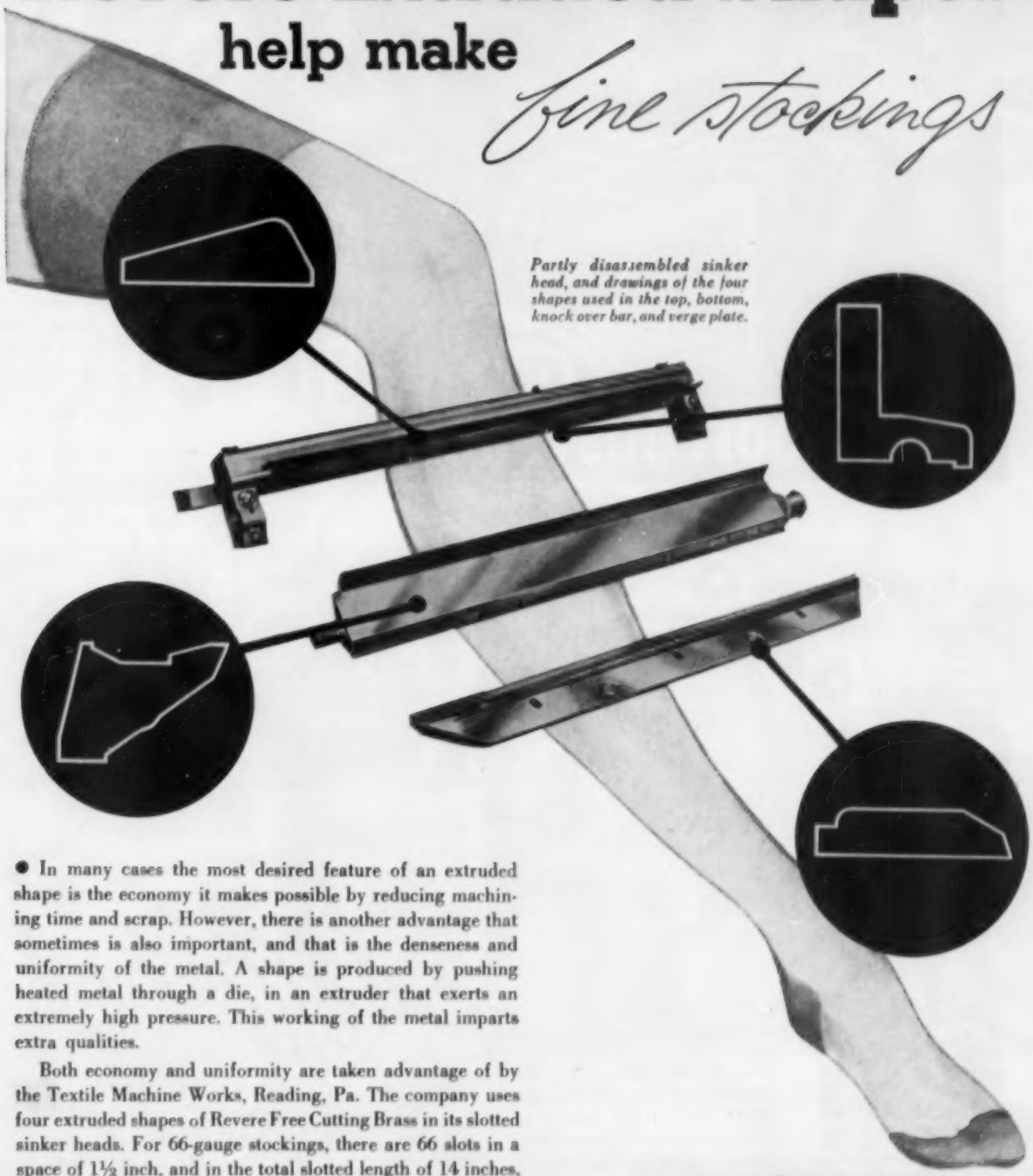
William H. Thomas, formerly manager of government sales for Air Products, Inc., Allentown, Pa., has been named director of the General Industrial Equipment Div., Business and Defense Services Administration, U. S. Department of Commerce. Mr. Thomas is on loan from his company under a rotation system whereby outstanding businessmen volunteer their services for periods of six months or longer without compensation from the government.

Chester F. Robards and **Del Steigerwald** have been added to the management staff of Chem-ray, Inc., Cleveland. Formerly, Mr. Robards was employed as chief metallurgist of the Cadillac Tank Plant, General Motors Corp., Cleveland. Mr. Steigerwald served as Cleveland district sales manager for the Harshaw Scientific Div. of Harshaw Chemical Co.

W. E. Johnston has been elected chairman of the board of trustees of the Johnston Mfg., Minneapolis, Minn. Mr. Johnston has been with the company since 1929.

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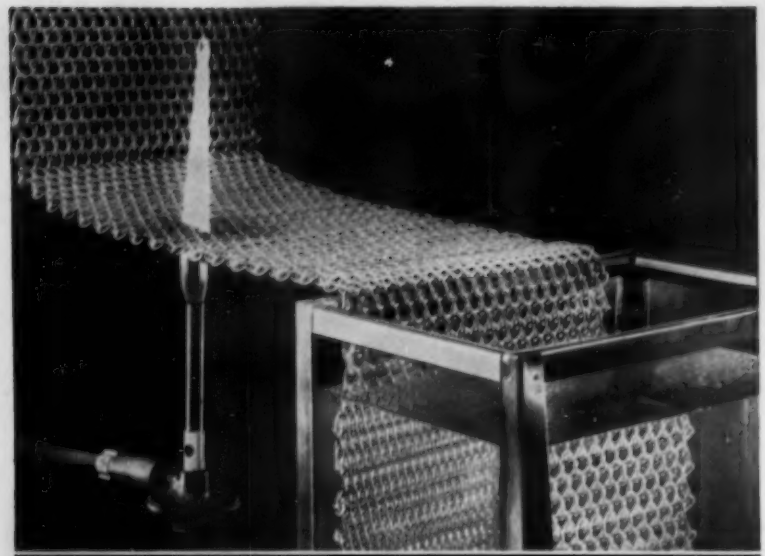
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Personals . . .

Edwin H. Crabtree recently was named director of the Colorado School of Mines Research Foundation, Inc. Mr. Crabtree, a 1927 graduate of Colorado Mines, was previously employed as deputy manager of the Grand Junction, Colo. Operations Office of the U. S. Atomic Energy Commission, joining the Commission in 1954. Prior to that time, he had been employed for 19 years by the Eagle-Picher Co.

Gregory Kobrin, recent recipient of a Bachelor's degree in chemistry from the University of Connecticut, has joined the Belle Works technical section of the polychemicals dept., E. I. du Pont de Nemours & Co., Charleston, W. Va.

John C. Coonley has been elected president and member of the board of the Hydraulic Press Mfg. Co., Mount Gilead, Ohio. Until January of this year, Mr. Coonley was general manager of the Valve Div. of A. C. F. Industries, Detroit. He previously was employed by the Heald Machine Co., Worcester, Mass., the Lucas Machine Tool Co., Cleveland, and the Walworth Co., Inc., New York.

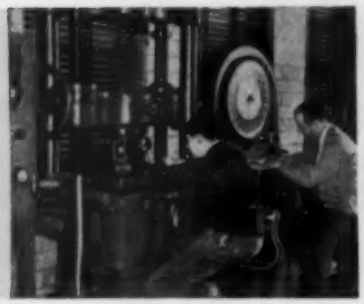
Wen Hsiang Chang, who recently joined the materials and processes laboratory of the General Electric Co.'s large steam turbine-generator dept., Schenectady, N. Y., has been appointed an applied research engineer. Dr. Chang received his Ph.D. degree from Rensselaer Polytechnic Institute last February; he also studied at the Missouri School of Mines, receiving his Master's degree in 1950, and at the National Hunan University, Hunan, China, receiving his Bachelor's degree in 1946.

Robert H. Jacoby has become an associate of the St. Louis Coke & Foundry Supply Co., St. Louis, Mo. Mr. Jacoby formerly was employed by the Key Co., East St. Louis, Ill., joining that company in 1938 as assistant metallurgist and advancing to the position of chief metallurgist and manager of quality control.

W. Bruce Clymer is now a metallurgist for Metallurgy, Inc., Newfield, N. J.

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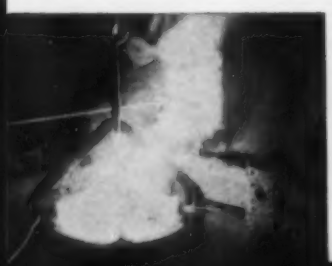


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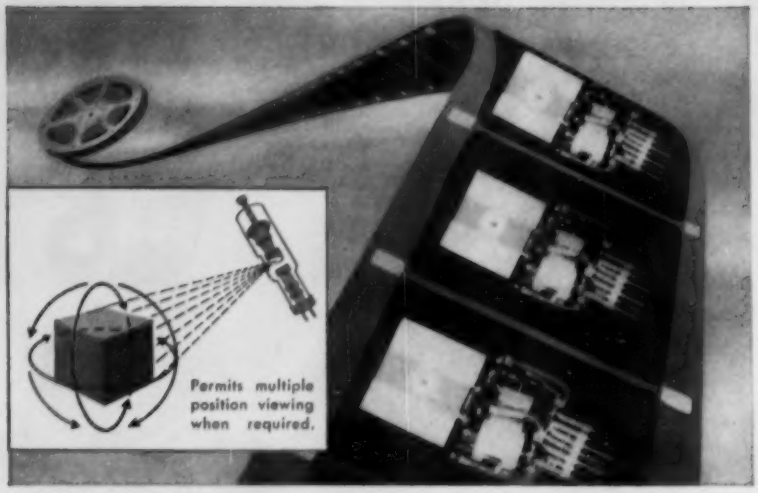
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Personals . . .

William H. Wills, Jr., formerly employed at Babcock & Wilcox Co., Beaver Falls, Pa., is now employed as a metallurgist at the Universal-Cyclops Steel Corp., Titusville, Pa.

John E. DeMoss has recently resigned as chief metallurgist of the Powder Metal Parts Div., Keystone Carbon Co., St. Marys, Pa. to accept the position of supervisor of metallography and high-temperature testing with the laboratory of the small aircraft engine dept. of General Electric Co., West Lynn, Mass.

David Swan has been appointed director of research of Metals Research Laboratories, Electro Metallurgical Co., a division of Union Carbide and Carbon Corp. Mr. Swan has been connected with Electro Metallurgical Co. since 1946.

William M. Akin, president of Laclede Steel Co., St. Louis, Mo., was elected vice-president of the American Iron and Steel Institute by the board of directors.

Wallace T. Gray was named general works manager of the Leece-Neville Co., Cleveland. Mr. Gray formally served as manager of the Camden, N. J. plant of the Radio Corp. of America and as plant manager for the Murray Ohio Mfg. Co., Cleveland.

W. William Nash has resigned as metallurgist in the materials and methods laboratory at Piasecki Helicopter Co., Morton, Pa., to accept the position of research metallurgist with the Burroughs Corp. at the research center in Paoli, Pa.

John C. Leutwyler, Jr. has been appointed general sales manager of the Heintz Mfg. Co., Philadelphia. Mr. Leutwyler has served the company since 1944 as manager of the Western Div.

Richard J. Greene has been placed in charge of the newly established Southeast States technical section of the International Nickel Co.'s development and research div., Atlanta, Ga. Mr. Greene, a graduate metallurgist of Rensselaer Polytechnic Institute, has been with the company since 1945, formerly serving as a member of the Atlantic Coast technical section.



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*U. S. Pat. #2184926 (other patents pending)



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Rotoblast Blastmaster II & Continuous-Flo Barrel



Rotoblast Tables & Table-Rooms



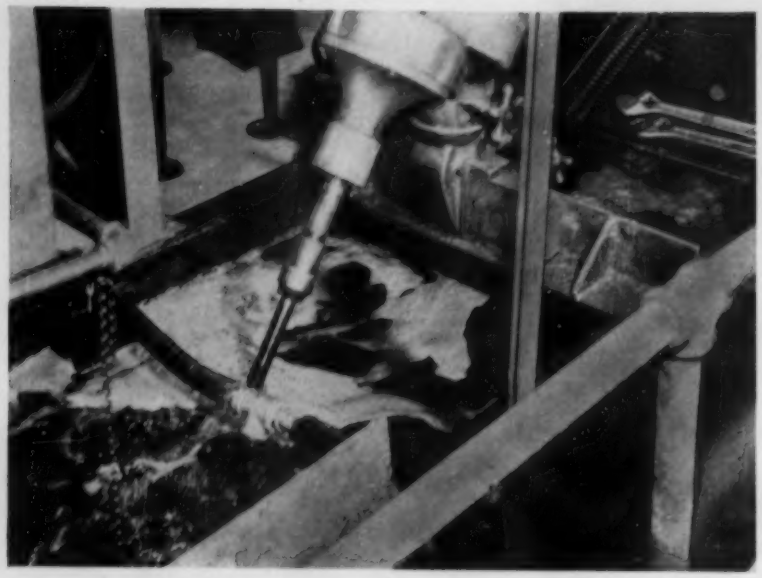
Special Blast Rooms & Cabinets



Pangborn Dust Control Equipment



Malleabrasive* Shot & Grit



Get UNIFORM QUENCH RESULTS *with engineered agitation*

If you're considering *violent turbulence* for your quenching operations, we'd like to drop this reminder:

Most of the people who use violent agitation in the quench bath do it with LIGHTNIN Mixers.

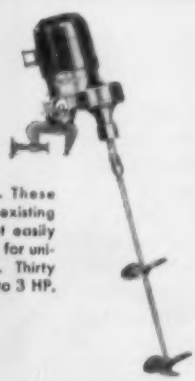
And without exception, these men report good heat treating results. Greater uniformity of hardness, all over the part and from one part to the next. Greater depth of hardness, resulting in higher over-all tensile strength and toughness. No re-treats and rejects due to soft spots. No warpage or cracking. For some steels, better machinability.

You can get LIGHTNIN Mixers for any type of immersion quenching, martempering, austempering; for use with any quenchant; any size, shape, and quantity of pieces, in new or existing tanks.

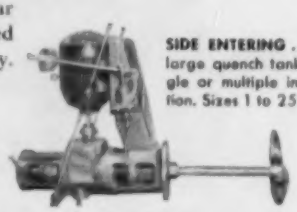
For information on the number, size, type, and cost of LIGHTNINs you will need to get the results you want, just call your nearest LIGHTNIN representative (listed in Thomas' Register) or write us today.



PERMANENT . . . Often used as a component of new quench tanks and heat treating furnaces. Sizes ¼ to 3 HP.



PORTABLE . . . These LIGHTNINs fit existing tanks, and adjust easily to the best angle for uniform turbulence. Thirty models; sizes ⅓ to 3 HP.



SIDE ENTERING . . . For large quench tanks; single or multiple installation. Sizes 1 to 25 HP.

"Lightnin" Mixers"

MIXING EQUIPMENT Co., Inc.

171-k Mt. Read Blvd., Rochester 11, N. Y.

In Canada. Greey Mixing Equipment, Ltd., 100 Miranda Ave., Toronto 10, Ont.

Personals . . .

Paul D. Gorsuch, a metallurgical engineer at the materials and processes laboratory, General Electric Co., Schenectady, N. Y., will now serve on the staff of the General Electric Research Laboratory at The Knolls, Schenectady, as a research associate in the metallurgy and ceramics dept.

Earl W. Beyerlein has been named casting buyer for the Axle Div., Cleveland, and the Forge Div., Marion, Ohio, of the Eaton Manufacturing Co. Mr. Beyerlein formerly was associated with J. I. Case Co., Honsell-Electric Co. and Koppers Co. as a metallurgist and with International Harvester Co. as a chemical analysist.

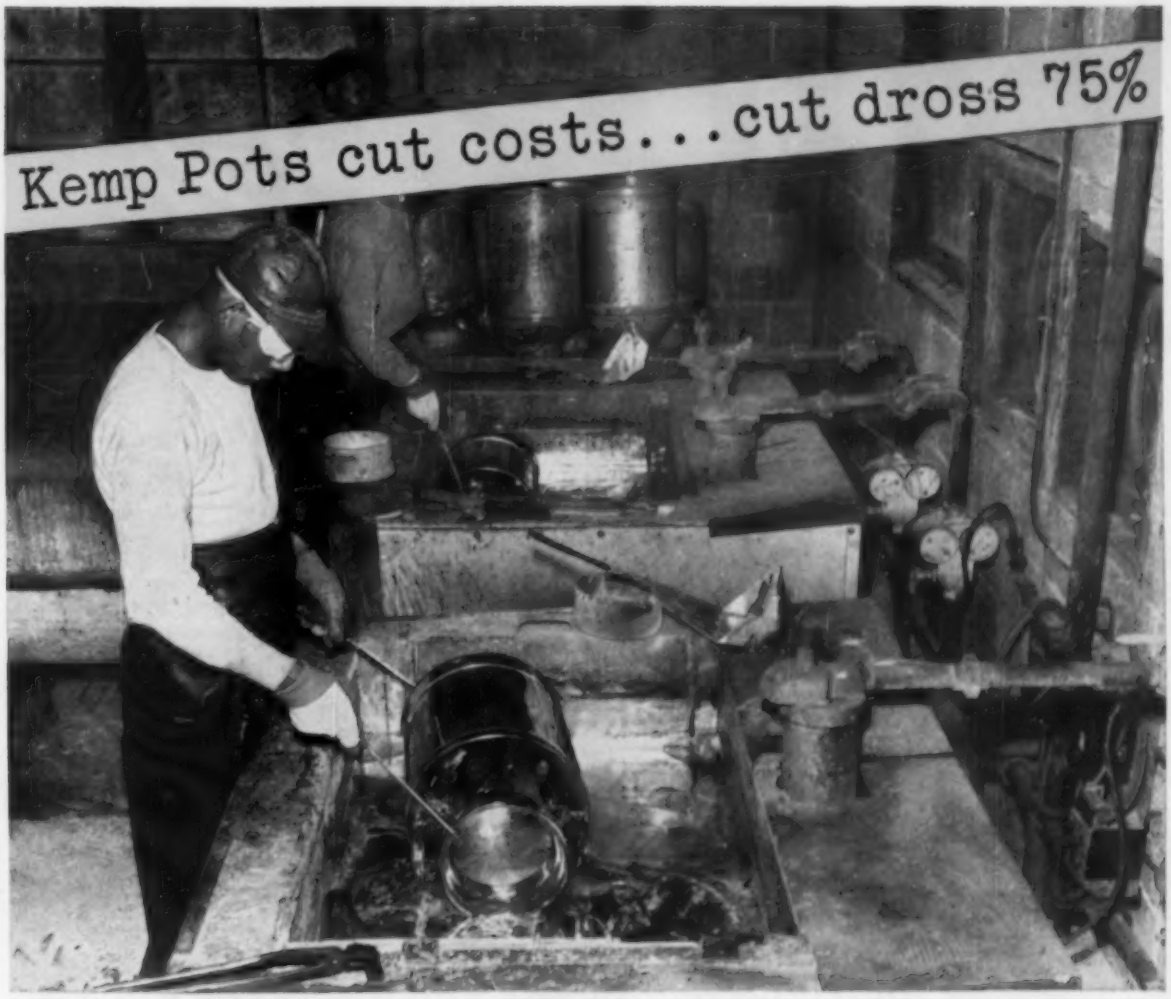
Gordon L. McMillin has been appointed vice-president, steel foundry, at the Canadian Car & Foundry Co., Ltd., Montreal, Canada. Mr. McMillin was previously asst. vice-president, steel foundry.

Edgar D. Flintermann has been elected executive vice-president of the Detroit Gray Iron Foundry Co., Detroit. Mr. Flintermann recently resigned as president of the Misco Corp., Detroit, a position held since 1952. From 1934 to 1952, he served as president of Michigan Steel Castings Co., Detroit, until that company was bought out and joined with several others to form the Misco organization.

V. H. Lawrence is retiring as vice-president, industrial relations, with Jones & Laughlin Steel Corp., Pittsburgh, on account of ill health. Mr. Lawrence has been with the company since 1942 and will maintain his association as consultant to the president.

William A. McKnight, formerly connected with the Houston office of Baldwin-Lima-Hamilton Corp., has been named manager of Baldwin's sales office in St. Louis, Mo.

Carl A. Keyser has been named full professor of mechanical engineering at the University of Massachusetts. Professor Keyser is a graduate of Worcester Polytechnic Institute and holds an M.S. degree from Carnegie Institute of Technology. He has been on the university staff since 1947.



Springfield Can Co. reports: *Improved retinning quality at lower cost with Kemp Melting Pots*

Retinning dairy equipment is the main plant operation at the Springfield (Missouri) Can Co. Milk cans are treated in a retinning room where 2 Kemp Immersion Heating Pots melt block tin and keep it in liquid form for the operation.

Installed in January, 1955, the Kemp Pots have already proved superior to the old, externally heated pots in quality control. They have reduced dross formation 75%. The constant, even heat of Kemp Pots helps produce heavier tin coatings, which give the retinned cans the quality appearance and life of new cans.

Kemp Saves Fuel, Production Time

The Kemp units heat much faster than old-fashioned methods and maintain an even temperature. This means lower fuel costs as well as valuable production time saved. Mr. Jack Simon, Springfield Can Co. owner, sums it up by saying, "The Kemp Melting Pot is the finest produced!"

Kemp Can Help You

You benefit in many ways when you install Kemp Melting Pots: they are not subject to periodic and expensive breakdowns . . . offer greater heating surface, faster heat recovery, lower dross formation, even lower room temperatures—they operate continuously at maximum efficiency with a substantial saving in fuel costs.

Find out how Kemp engineers can provide the most profitable solution to your heating or melting problem. Write for Bulletin IE-10 today.

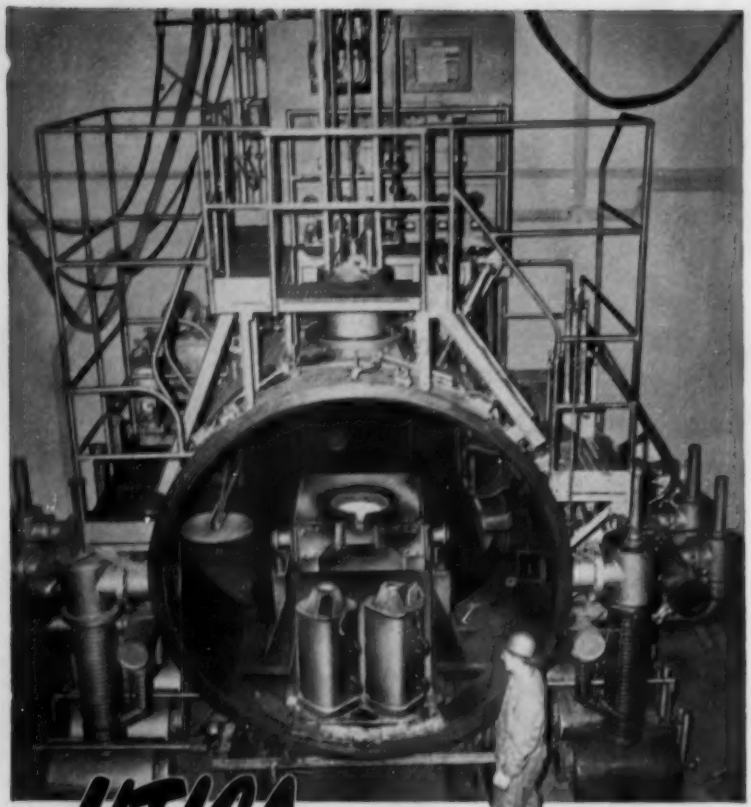
KEMP OF BALTIMORE

IMMERSION MELTING POTS



CARBURETORS • BURNERS • FIRECHECKS • ATMOSPHERE & INERT GAS GENERATORS • ADSORPTIVE DRYERS SINGEING EQUIPMENT

THE C. M. KEMP MFG. CO.
405 East Oliver Street, Baltimore 2, Maryland



UTICA ... Major Supplier of Vacuum Melted Alloys to the Aircraft Industry

UTICA Vacuum Melting Assures:

Metals of very high cleanliness with virtual elimination of inclusions and contaminants.

Maximum uniformity of chemical composition from melt to melt.

Greatly improved physical properties to withstand extreme stresses, particularly at high temperatures.



For the full story of UTICA *Metals Division vacuum melting, send for this brochure.*

Offer of our facilities is subject to priority of national defense orders.

With the output of a second 1000-pound furnace—in addition to other smaller furnaces—the Metals Division at UTICA has become one of the largest producers of vacuum melted alloys.

Experience gained in literally hundreds of melts has led to regular and consistent volume production with the most rigid control of the properties of the alloys.

In addition, UTICA, alone, offers not only static but ***centrifugal*** castings as well. The latter often permit significant reduction in costs.

The Metals Division at UTICA invites inquiries from prospective customers. Through refinements in technique, costs are constantly being reduced—and the Division is glad to work closely in resolving the customer's metallurgical problems.

Utica Metals Division

U DI MET™ ALLOYS

UTICA DROP FORGE AND TOOL CORP., UTICA, N. Y.

Personals . . .

Orville T. Barnett has been promoted to assistant manager of the metals research department at Armour Research Foundation of Illinois Institute of Technology. A 1933 graduate of Illinois Tech, Mr. Barnett joined the Foundation in 1954 as supervisor of welding research in the metals research department. Prior to that date he was regional sales manager for the A. O. Smith Corp. in Chicago.

Robert N. Honeyman, formerly associated with Thompson Products, Inc., Cleveland, is now a metallurgical engineer with the General Electric Co. at the Knolls Atomic Power Laboratory, Schenectady, N.Y.

Michael J. Norman has been named technical representative in charge of the metallurgical section at Carveth Metallurgical, Ltd., Toronto, Canada. Mr. Norman was previously employed for five years as a laboratory technician at Orenda Engines, Malton, Canada.

P. M. Unterweiser has recently joined the staff of the **Iron Age** as metallurgical editor. Prior to this appointment he was metallurgical engineering supervisor of heat treat process, Wright Aeronautical Div., Wood-Ridge, N. J.

David Kramer was the recent recipient of a Bachelor of Science degree from Massachusetts Institute of Technology and is now studying for his Master's degree at Columbia University.

S. P. Magnano is now serving in the U.S. Navy as an ensign and is attending the Naval Supply Corps school at Athens, Ga. Prior to his service in the Navy, Mr. Magnano was employed at Pratt & Whitney in East Hartford, Conn. as a junior metallurgist, following his graduation from Rennselaer Polytechnic Institute in June of this year.

V. E. Lysaght, recently appointed general sales manager of American Chain & Cable Co., was a featured speaker at the Second International Conference on Hardness Testing, held Sept. 22 to 23, at Bremen, Germany. Mr. Lysaght spoke on "Recent Developments in Rockwell Testing in the United States".



TOOL STEEL SHEETS



STAINLESS STEEL BAR STOCK



CARBON STEEL WIRE

You can safely descale most metals in 20 minutes or less

WITH THE DU PONT SODIUM HYDRIDE PROCESS



In 10 to 20 minutes, sheets, bars, wire, rods, forgings and fabricated articles are completely descaled with the Du Pont Sodium Hydride Descaling Process. Even heavily scaled forgings (½" scale thickness) take less than an hour. And in only 15 seconds you can get cold reduced-annealed strip clean and bright!

With hydride descaling, there's never any danger of etching or pitting . . . never a costly reject due to loss of gauge. Base metal is always protected, *since bath action stops the instant scale is reduced.* And retreatments are rarely needed with most metals. One pass through the sodium hydride bath will do the job completely.

TECHNICAL SERVICE AVAILABLE

If you are descaling metals which are unaffected by fused caustic at 700°F., it will be to your advantage to talk to us about the Du Pont Sodium Hydride Process. Du Pont pioneered this modern descaling method and can bring a depth of technical experience to bear on your descaling problems.

There's no cost for this service which includes laboratory investigation of problems, plus expert aid in construction, installation and operation of the process. Just call our nearest district office or send in coupon below.

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Electrochemicals Dept., Wilmington 98, Del.

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☐ Please have one of your technical men call. I am interested in descaling _____

Name _____

Firm _____

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DURALOY

A good example of our
WELDING
TECHNIQUE

in connection
with high
alloy casting

This tube support is 21'6" long; 6'7" wide and weighs 8900 pounds. It looks like a single casting. Actually it is made up of three sections welded together in zig-zag strips across the face. It's a Duraloy HH casting destined for an oil refinery cracking still.

Welding is assuming greater and greater importance in the production of high alloy castings. Often it is the only way to produce large tonnage or unusually shaped pieces. During our many years of experience in producing both high alloy static and centrifugal castings, we have developed sound welding techniques for such castings. Carbon steel welding techniques won't serve. It takes special know-how for chrome-iron and chrome-nickel.

You can rest assured that if the chrome-iron or chrome-nickel castings you order from us require any welding, it will be done skillfully.

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OFFICE AND PLANT: Scottdale, Pa.
EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
DETROIT OFFICE: 2306 Woodward Avenue, Pleasant Ridge, Mich.
CHICAGO OFFICE: 332 South Michigan Avenue

Personals . . .

Charles E. Lapple, former associate professor of chemical engineering at Ohio State University, has joined the chemical and metallurgical engineering section of Stanford Research Institute's physical sciences division. A graduate of Columbia University, Mr. Lapple worked in the engineering research laboratory of E. I. du Pont de Nemours and Co., Wilmington, Del., and during the past five years has been a consultant to industry as well as a professor.

David C. McVey has joined the Chicago office of Climax Molybdenum Co. as a sales development manager. A graduate of Carnegie Institute of Technology, Mr. McVey formerly was a metallurgist with International Harvester Co. and a plant metallurgist at the propeller division, Curtiss-Wright Corp., Caldwell, N.J.

John W. Weyers, formerly welding engineer with General Electric Co., Syracuse, N. Y., is now employed as a research engineer for North American Aviation, Inc., Downey, Calif.

John G. Thomas has been transferred from toolsteel service engineer, Crucible Steel Co. of America, Syracuse, N. Y., to the position of service metallurgist for the New York-New Jersey sales office.

Howard J. Siegel, formerly associated with the Kentucky Research Foundation and the University of Kentucky, is now metallurgist, chemical and metallurgical section, physical test laboratory, McDonnell Aircraft Corp., St. Louis, Mo.

Duane J. Schmatz has started a nine-month training program at Caterpillar Tractor Co., Peoria, Ill. After completing three months, Mr. Schmatz will return to the University of Wisconsin to obtain his master's degree in metallurgical engineering.

Leroy W. Davis has recently been appointed manager of the forging division of the Harvey Machine Co., Inc., Torrance, Calif. Mr. Davis has been associated with the aluminum forging industry for many years. His previous connections were with Kaiser Aluminum and Chemical Corp. and the Aluminum Co. of America.

FORD MOTOR

increases strength of this assembly and...

SAVES UP TO 20%



FORGINGS WERE BUTT-WELDED SINGLY—
FLASH WAS SHAVED OFF AND JOB BUFFED.





FOUR ASSEMBLIES ARE NOW BRAZED SIMULTANEOUSLY—
NO GRINDING AND BUFFING NECESSARY AFTER BRAZING.



SILVALOY

LOW TEMPERATURE SILVER BRAZING ALLOY

PREFORMED RINGS ARE USED FOR THE JOB!

SEND FOR FREE GUIDE TO SUCCESSFUL SILVER BRAZING

The successful combination of Ford Engineering and Silvaloy Brazing Alloy multiplies production efficiency for this Ford Transmission Gearshift Tube and Socket assembly—*with important savings in costs!* Formerly, single assemblies were butt-welded, the flash removed and joint buffed. Now, four assemblies are brazed simultaneously—without need for grinding or buffing after brazing. A Silvaloy Technician will be glad to assist in planning brazing production in your plant, to help you cut costs, improve results and speed production. Call or write today. There's no cost or obligation, of course. ★ ★ ★ ★ ★ ★ ★



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SEATTLE, WASH. • PORTLAND, ORE.
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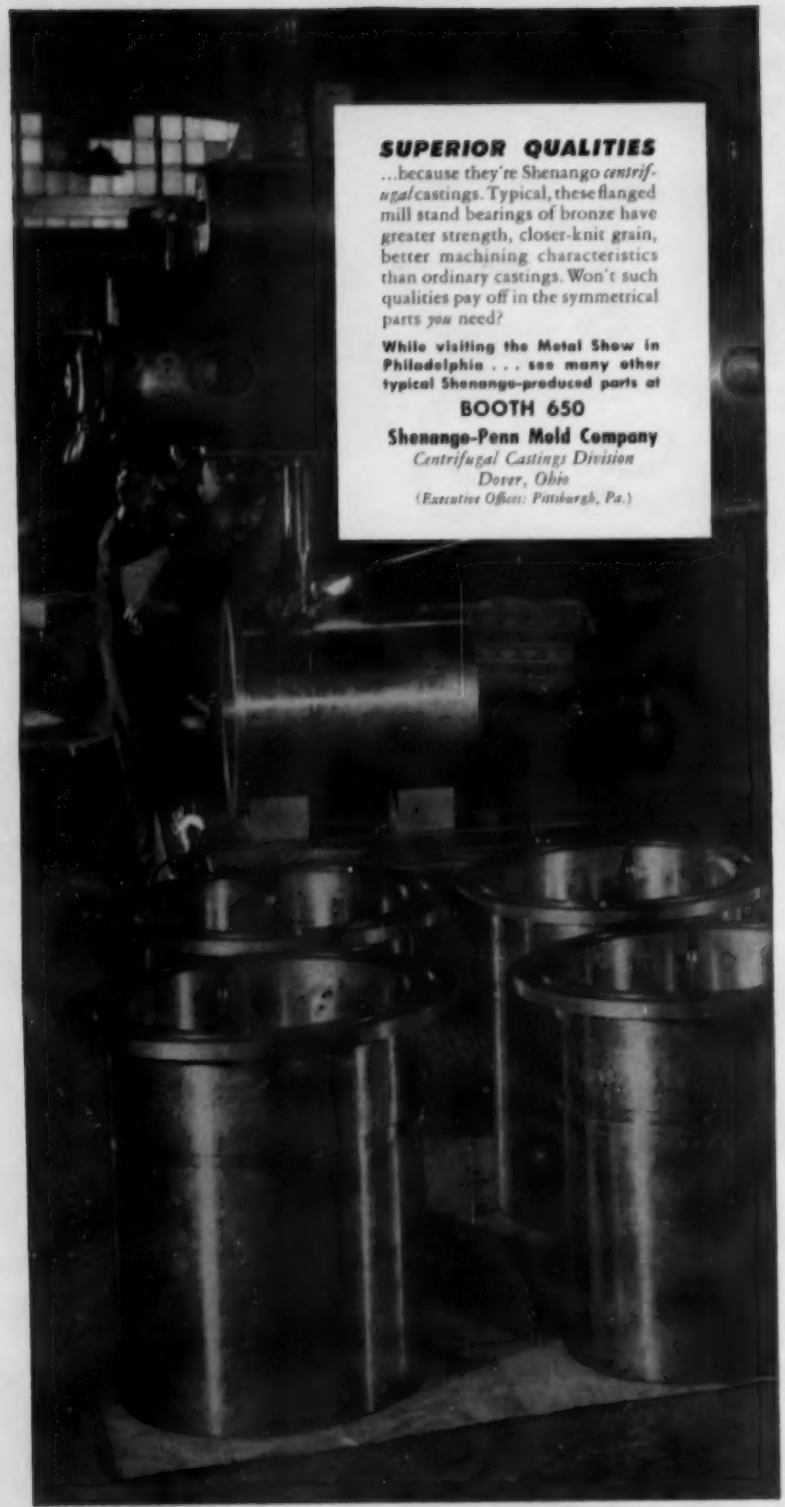
PACIFIC METALS COMPANY LTD.
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LICENSED CANADIAN MANUFACTURER
BAKER PLATINUM OF CANADA, LTD.
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THE AMERICAN PLATINUM WORKS

231 NEW JERSEY RAILROAD AVENUE • NEWARK 5, NEW JERSEY



Personals . . .

Mortimer F. Sayre has retired from active teaching at Union College and is now professor emeritus of mechanical engineering, continuing his consulting work and other activities. Professor Sayre is a past chairman of Eastern New York Chapter.

Robert H. Kaltenhauser, having completed a two-year tour of duty in the U. S. Army, is in the research laboratory of Allegheny Ludlum Steel Corp., Brackenridge, Pa.

Donald L. Crews, for the past seven years assistant professor of metallurgical engineering at the University of Cincinnati, has joined James B. Clow & Sons Co. as director of a research and development department to be located at the Coshocton, Ohio, plant.

Owen M. Katz is employed as research metallurgical engineer at the research laboratory of Jones & Laughlin Steel Corp., Pittsburgh.

Melvin H. Knapp has been named chief metallurgist for Brown & Sharpe Mfg. Co., Providence, R. I.

D. O. Leeser has resigned from the Argonne National Laboratory, Chicago, to join the staff of the Detroit Edison Co. in the nuclear power development department. Mr. Leeser heads the materials section, and is consultant to the nuclear reactor project, Atomic Power Development Associates, Inc., on materials selection and specifications. As a member of the reactor engineering division at Argonne, he worked on the power plant for the first nuclear-fueled naval vessel, "Nautilus", and on the initiation of work on such power reactors as EBR-II. Previous to joining Argonne, Mr. Leeser was a member of the research staff of the Battelle Memorial Institute, Columbus, Ohio.

Frank E. Robinson has joined the testing division of Douglas Aircraft Co., Santa Monica, Calif., as a materials and process engineer.

Edward L. Badwick has received a Master of Science degree in metallurgy from Stevens Institute of Technology and is employed as a metallurgical engineer for the Red Bank Div., Bendix Aviation Corp., Eatontown, N. J.

color-glance

BRINELL HARDNESS TESTER



See it demonstrated
METAL SHOW
BOOTH 324



Automatically signals relative hardness

TOO HARD — Yellow

WITHIN RANGE — Green

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Models
KDR-6E
KDR-10E

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OUTSTANDING FEATURES

- Machine decides which pieces are of proper hardness.
- Dependable, repeat performance. Up to 800 tests per hour.
- Designed for minimum maintenance and simple operation.
- Adaptable to most Brinell testing jobs.

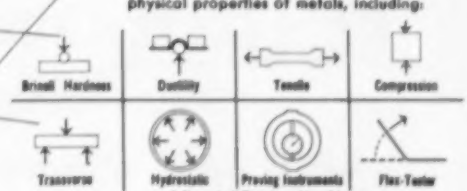
* * *

Get the facts about "Color-Glance". Write today for complete information and name of nearest representative.

Steel City Testing Machines Inc.

8807 Lyndon Ave. • Detroit 38, Mich.

Manufacturers of machines for testing physical properties of metals, including:

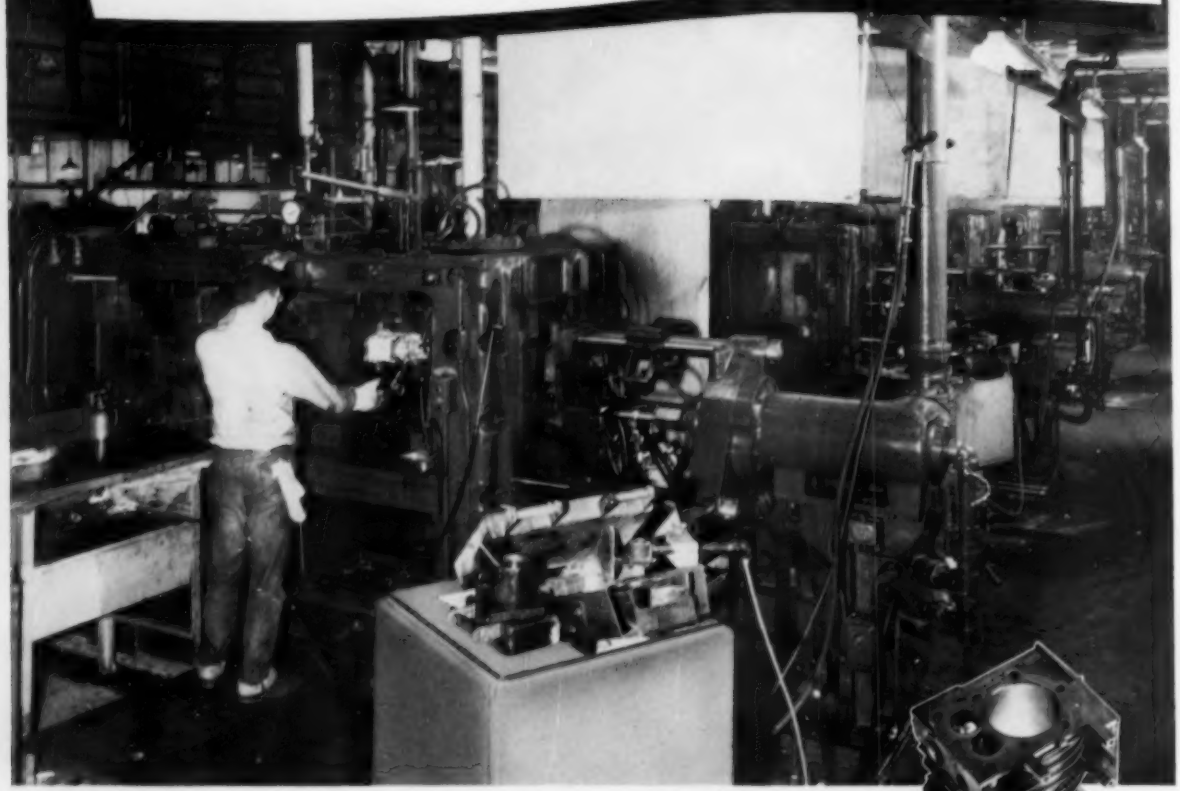


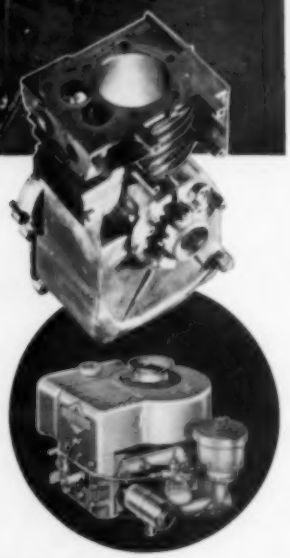
. . . and Special Testing Machines.

Color-Glance makes possible automatic Brinell testing

SUPER DENSE DIE CASTING

Forms Cylinder Wall for Gasoline Engine





The die cast aluminum cylinder block used by Briggs & Stratton on their famous 4 cycle, gasoline engines is a credit to the technical skill of our customer and the ability of the die casting machines on which the whole concept was based.

This die casting, produced on a battery of Lester HP-3-1/2X-SF die casting machines, is so dense that the aluminum itself is used as the cylinder wall against which the piston travels. No sleeve or liner of any kind is used—the only thing required is a simple honing operation.

If you buy, sell or use die castings of any size or for any use, you can get comparable quality—with Lester equipment.

LESTER DIE CASTING MACHINES

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distributed by LESTER-PHOENIX, INC., 2619-S CHURCH AVENUE • CLEVELAND 13, OHIO



this attractive new dispenser of STAINLESS STEEL

meets every standard for cleanliness and top design

The Norristocrat is the newest addition to the line of milk dispensers manufactured by Norris Dispensers, Inc., of Minneapolis, Minnesota. It's designed by Raymond Loewy Associates and, like many Norris dispensers, it's Crucible stainless steel *inside and out.*

INSIDE, it's stainless to keep milk dairy-fresh, with flavor unchanged . . . to make cleaning easier . . . to meet all sanitary codes . . . and to satisfy the most exacting demands of schools and hospitals across the nation.

OUTSIDE, it's stainless to insure an attractive, lasting appearance that complements its clean, modern design . . . and adds to its promotional effectiveness for encouraging the consumption of milk.

Cleanability, product protection and bright good looks are the main reasons Norris insists on stainless steel. But stainless offers many other properties, too — among them corrosion and heat resistance, high tensile strength, excellent workability. And you'll find exactly the combination and degree of these properties you need in one of the thirty grades of Crucible stainless steel. To see what general and technical literature is available to help you make the most of Crucible stainless — or any other Crucible special purpose steel — write for your free copy of the Crucible Publication Catalog. *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 22, Pa.*

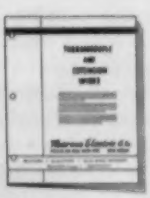
CRUCIBLE first name in special purpose steels

Crucible Steel Company of America



Here's how a reel of T-E wire looks after you unwrap it. The easy-to-read label can save valuable time when you must know, and know quickly, what kind of wire is on the reel. The label tells you not only wire type, length, and polarity, but insulation colors too. Therefore, you can identify conductors easily by comparing colors listed on the label with those on the wire itself.

As you can see, it's a well-thought-out label. Important by itself, it's also a revealing illustration of the care T-E takes. Thoroughness is characteristic of every step in T-E's wire production, from drawing and calibrating to insulating. The result of such care is a product which meets high industrial standards.



There are too many T-E wires to mention comfortably in one ad. However, in T-E's 8-pg. Wire Bulletin you can see insulations, gages, and calibrations, as well as charts with calibration symbols, color codes, insulation characteristics, resistances, weights, electrical properties, and conduit capacities. Write for Bulletin 31-H.

Pyrometers • Thermocouples • Protection Tubes • Quick-Coupling Connectors
Thermocouple and Extension Wires • Resistance Bulbs • Connector Panels

Thermo Electric Co., Inc.
SADDLE RIVER TOWNSHIP, ROCHELLE PARK POST OFFICE, NEW JERSEY
IN CANADA—THERMO ELECTRIC (Canada) Ltd., BRAMPTON, ONTARIO

Personals . . .

Clark E. Miller has been transferred from Ford Motor Co.'s Kansas City, Mo. aircraft plant to the assembly plant at Mahwah, N. J., as manager of material quality.

Everett R. Turner is employed as metallurgical supervisor in the department of research and development, Canadian National Railways, Montreal.

Robert G. Henning is now on active duty as second lieutenant with the U. S. Air Force as a project officer in the design criteria section, metals branch of the materials laboratory, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio.

Jack T. Mommsen received the degree of Master of Science from the University of Arizona in May 1955, and is employed by the General Electric Co. as a metallurgical engineer, fuel technology, engineering department, Hanford Atomic Products Operation, Richland, Wash.

Braley S. Myers, who formerly supervised the research programs on metal finishing, surface preparation, metal cleaning and corrosion in the manufacturing research department of International Harvester Co., Chicago, has been transferred to the general office of the company as materials engineer.

Lawrence Lewis, who received a B.S. degree in metallurgical engineering from New Mexico Institute of Mining and Technology last June, has been awarded a William E. Gotshall Scholarship at Lehigh University, where he is now enrolled.

John R. England, formerly service metallurgist in the Cleveland district of United States Steel Corp., is now a staff metallurgist, alloy steels, in Pittsburgh.

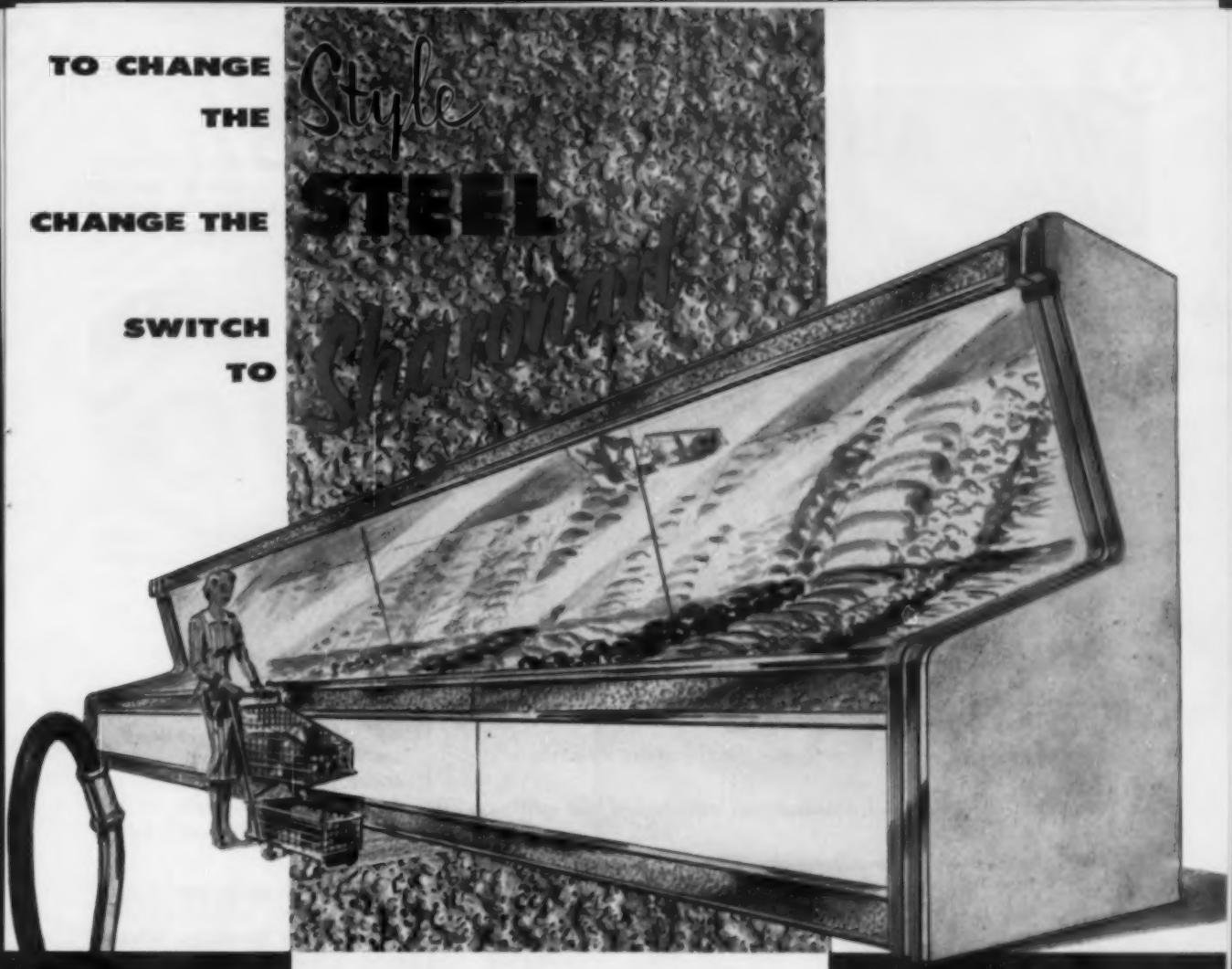
Dean Kneale Hanink has been transferred from the research division of General Motors Corp., Detroit, to the Allison Div., Indianapolis, Ind., where he holds the position of chief metallurgist.

Arlen S. Kjelby has been released from active duty in the U. S. Navy and is working as a research metallurgist at National Cash Register Co., Dayton, Ohio.

TO CHANGE THE STYLE

CHANGE THE STEEL

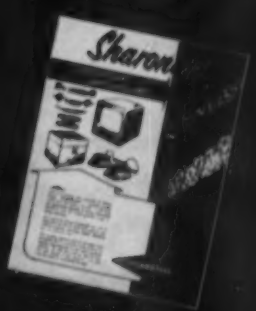
SWITCH TO Sharonart



SHARONSTEEL

Another quality of Sharonart—the rolled-in design steel—is its ability to resist marring. This makes it the ideal material for products that must withstand constant abuse—sweepers, display counters, business machines, metal furniture, cabinet and door hardware and so forth.

There are many other reasons why leading designers are finding more and more applications for Sharonart. What about your product? For complete information contact the Sharon office nearest you, or write direct for your copy of the new Sharonart booklet.





SHARON STEEL CORPORATION

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Personals . . .

John C. Barrett is now a metallurgist on the staff of the Assistant Secretary of Defense, Research and Development, Washington, D. C.

Jack C. Bokros is now employed as a research engineer in the nuclear engineering and manufacturing division of North American Aviation, Inc., Long Beach, Calif.

Read M. Kyhns, Jr. has been named plant metallurgist for the bearing division of Bohn Aluminum and Brass Corp., Greensburg, Ind.

Dirk G. Rabenold has been transferred by the Westinghouse Electric Corp. from the metallurgical development section to the newly formed materials manufacturing group, where his major concern will be with heat treating problems.

E. T. Armstrong, general manager of Toscony Fabrics, Inc., Passaic, N.J., has organized and is operating a consulting engineering service in engineering physics, specializing in the solution of problems in research or development on processes or products.

Peter C. Rossin, formerly a research associate at General Electric Co.'s research laboratory, Schenectady, N.Y., is now employed by the Universal-Cyclops Steel Corp., Bridgeville, Pa., as a research associate engaged in pilot-plant activities on vacuum melting.

James R. Cone, having completed requirements for a degree in metallurgical engineering at Purdue University, has been employed as a trainee in openhearth management at Gary Works, U.S. Steel Corp., Gary, Ind.

William B. Womack has been appointed general manager of Cook Heat Treating, Inc., Los Angeles, a subsidiary of A. F. Holden Co. of Mich. Mr. Womack has been with the company 14 years and prior to his recent appointment was plant superintendent.

Norman W. Johnson has resigned his position as principal metallurgist at Battelle Memorial Institute, Columbus, Ohio, and is now associated with Eaton Mfg. Co. of Detroit, Mich.



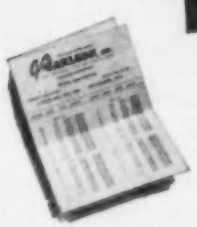
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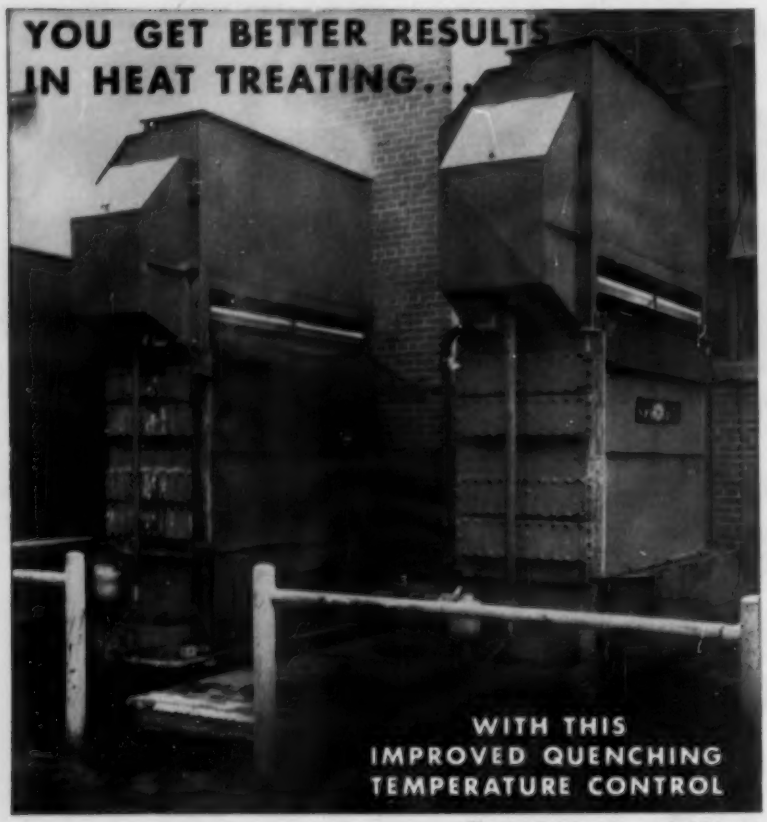


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District Engineers in Principal Cities of United States and Canada

Personals . . .

George E. Dieter, Jr. has been relieved from active duty as special projects officer, Ballistics Research Laboratory, Aberdeen Proving Ground, Md., and is now a research engineer at the engineering research laboratory, E. I. du Pont de Nemours & Co., Wilmington, Del.

Harold H. Johnson is now director of research at the research laboratory of the National Malleable & Steel Casting Co., Cleveland. Mr. Johnson had spent 16 years at the Sharon Works of the company in Sharon, Pa., prior to his recent appointment and last held the position of chief metallurgist there.

Paul Shewmon recently received his Ph.D. degree in metallurgy from Carnegie Institute of Technology and is now employed in the research laboratory of Western Electric Co., East Pittsburgh, Pa.

A. E. Franks, formerly production manager at the Vacuum Metals Corp. plant in Cambridge, Mass., is now melt shop superintendent at the company's new location in Syracuse, N.Y. As a result of a merger with Crucible Steel Co. of America, Vacuum Metals Corp. moved its production facilities from Cambridge to Syracuse. The company is jointly owned by Crucible Steel and National Research Corp.

David Springsteen, a former student at Harvard University's Graduate School of Business Administration, is on active duty with the United States Air Force as a second lieutenant. He is assigned to the materials and thermodynamics section, Lewis Flight Propulsion Laboratory, National Advisory Committee for Aeronautics, Cleveland.

Denis Ramball recently graduated from Lehigh University, receiving a B.S. degree in metallurgical engineering, and is now employed in the mill metallurgical department of Crucible Steel Co. of America at the Syracuse, N.Y., works.

Watt W. Webb has received his Sc.D. from Massachusetts Institute of Technology and is returning to the Metals Research Laboratories of Union Carbide and Carbon Corp., Niagara Falls, as a research metallurgist.

The SPEED QUEEN Story . . .

Carburizing Production Increased with

Park KASE 5-C*



PROBLEM Speed Queen Corp. of Ripon, Wisconsin, planned a 400% increase in the production of Speed Queen Automatic Washers.

More capacity, more production—about 4 times that of before World War II—was the basic problem facing the heat treat department. Most of this increase must be in carburized parts.

Problem two was extremely limited floor space. With the existng building, only 16 x 24 feet of floor space was available for furnaces, controls and quench tanks.

PARTS 22 different washing machine parts. Steel B-1113, C-1213, SAE 1020. Case depths .010-.028" required. One typical part is a B-1113 "double end pinion". Required case depth .028". Others are toggle levers, plates, rollers, etc. Case depths desired are .010" and up. Parts shown at the right.

SOLUTION Speed Queen installed two electric liquid carburizing furnaces containing Park Kase 5-C and one tempering furnace using Park Thermo-Quench Salt. Only 64 square feet of the 224 available was required. Park Kase 5-C at 1650°F produced high quality carburized cases from .010 to .028" as required. Oil quenched parts are cased .028" in 2 hours at 1650°; .010" in 30 minutes. Water soluble Park Kase 5-C permits parts to be easily washed completely clean. Speed Queen reports a complete absence of rejects and reworks as well as much lower costs.

***Park Kase 5-C is a liquid salt bath carburizing compound. It is water soluble, combining ease of cleaning with rapid carburizing rates. PK5-C is equally effective for light case, high dragout work and long cycle, deep casing applications.**

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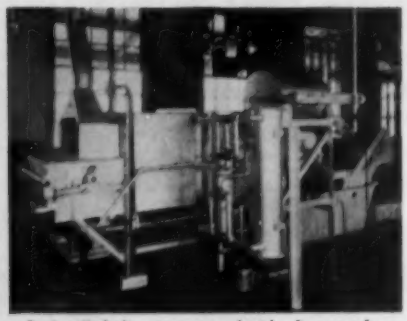
Park technical lab has facilities to run samples of your products. We would be glad to suggest a solution to your problems without obligation.

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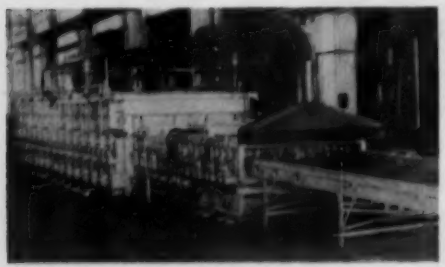
Improved Production through Better Heat Processing



Rockwell standard batch type, recirculating oven; gas, oil or electric; for annealing, drawing, aging or baking to 900° F.



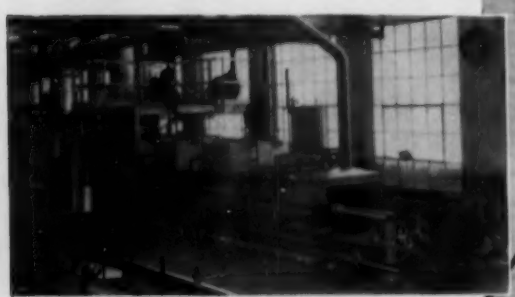
Rockwell belt conveyor, electric furnace for bright hardening small springs in controlled atmosphere; work conveyed automatically from furnace through quench tank to discharge.



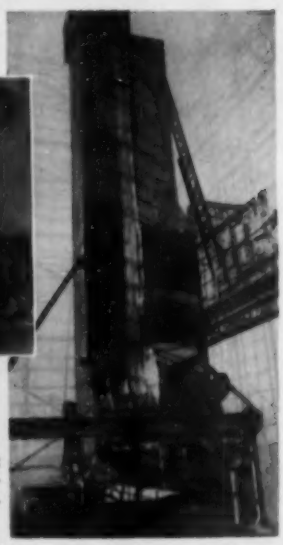
Rockwell continuous roller hearth furnace, gas-fired, for clean annealing brass and copper tubing at approx. 7000 lbs. per hour.



Right—Rockwell car type gas-fired furnace with unique construction heating and recirculating features for heating steel loads up to 50,000 lbs. at 1600° to 2200° F., and stress relieving at 1275° F. to 1600° F.



Rockwell continuous belt conveyor, muffle type, gas-fired furnace with long cooling section for bright annealing copper products in controlled atmosphere.



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Personals . . .

Robert C. Whitcomb has been transferred from the position of assistant metallurgist with American Manganese Steel Div., American Brake Shoe Co., Chicago, to plant metallurgist with Brake Shoe & Casting Div., American Brake Shoe Co., Baltimore, Md.

Erik B. Anderson has left his position as West Coast metallurgist for the Crucible Steel Co. of America to join Brander Industries, Inc., North Hollywood, Calif., as consulting metallurgist.

Eugene W. Emmerich is now working for Rem-Cru Titanium, Midland, Pa., in production engineering and control.

H. C. Swett has recently been appointed chief metallurgical engineer for Bethlehem Pacific Coast Steel Corp., San Francisco. Mr. Swett was previously employed as assistant general superintendent of the Los Angeles plant of the same company.

Roger Sutton has joined the development and research division of the International Nickel Co., New York, as a member of the stainless steel and heat resistant alloy section. Mr. Sutton spent five years as senior metallurgist at the Argonne National Laboratory prior to joining International Nickel.

Swen J. Olaussen, formerly assistant technical advisor for the New Bedford Div., Revere Copper & Brass Co., New Bedford, Mass., has been appointed technical advisor for the division.

Frank H. Sebring is now employed by the Scovill Mfg. Co., Waterbury, Conn., as a technical service engineer. Mr. Sebring was formerly connected with the Freeport Sulphur Co., Freeport, Texas.

David Street has been employed by the General Electric Co. in the Aircraft Nuclear Propulsion Dept., Cincinnati, Ohio, as an engineer. Mr. Street was previously employed by the Consolidated Vultee Aircraft Corp.

Arthur F. Lockwood is now a metallurgical trainee at the Kaiser Aluminum and Chemical Corp. plant in Newark, Ohio.

MIDVALE FORGES 7-TON GEAR RIM



Checking tooth contact on low speed gear, after being cut from Midvale forging. (Photo: General Electric)

For Seven Seas Service

Official U.S. Navy photo

Moving 60,000-ton ships is no job for weaklings. It takes real power . . . lots of it . . . and machinery strong enough to transmit that power to whirling propellers.

Rims for four low-speed gears, used in the General Electric Company's propulsion units totalling more than 200,000 HP (enough to furnish electricity for a city of 1½ million people) for the aircraft carrier USS SARATOGA, were forged by Midvale to convert that power into motion. Rough machined, each weighed 15,640 lbs., approximately, but each required a 73,500 lb. ingot to have a heart big and tough enough for the job.

Inherent alloy strength was developed by proven heat treatment to meet requirements for strength and wear. Machining was supervised by craftsmen with the experience and equipment to handle rough or finish machining of virtually any size.

Careful workmanship . . . in steel making, forging, inspection, machining . . . has earned for Midvale forgings, for over fifty years, their reputation for excellent performance and long life.

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WROUGHT ALLOY, strong, dense, uniform . . . gives thinner sections more rapid heat transfer, less hot spots, faster recovery.

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ALLOY WELDS X-ray-inspected . . . free from slag, air pockets, cracks. No premature failures due to these causes.

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Rolock fabricated, welded wrought Inconel construction assures a pot that has proved superior in every way for service with neutral salts. Rolock quality standards are backed up by final X-ray inspection before shipment. If you use neutral salt bath pots of this type (in any size or depth), write for specifications and quotation. Other important Rolock fabricated heat and corrosion-resistant alloy equipment is equally good. Please outline your requirements for analysis.

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SRL55

Personals . . .

L. W. Cashdollar, formerly metallurgical engineer at the Pittsburgh Metallurgical Co., Inc., Pittsburgh, has been transferred to the Cleveland office of the company as district manager.

J. S. Parsons is now employed as assistant plant engineer for Pacific Smelting Co., Torrance, Calif. Mr. Parsons formerly was with Western Pyromet Corp., Manteca, Calif.

Ralph B. Wessel has become the co-owner of the Foothill Foundry, Azusa, Calif. Mr. Wessel formerly was a process engineer at Douglas Aircraft Co., Inc., El Segundo, Calif.

Bernard W. Schaaf, a former research associate at Rensselaer Polytechnic Institute, is now employed as an engineer in the fuel element section of the submarine thermal reactor and the submarine fleet reactor projects at the Atomic Power Division of Westinghouse Electric Corp. in Pittsburgh.

Cdr. Edmund J. Wheelahan has been transferred from high-temperature metallurgist, Bureau of Aeronautics, Washington, D.C., to superintendent of the Aeronautical Materials Laboratory, Naval Air Materials Center, Naval Base, Philadelphia. Cdr. Wheelahan, a graduate of Rensselaer Polytechnic Institute, served in the Navy from 1941 to 1946 and was later recalled in 1951.

Harry J. Gilliland has been transferred from the Buick-Oldsmobile-Pontiac Div. of General Motors, Kansas City, where he was in charge of the manufacturing and development section of the laboratory for the F84 aircraft program. He is now senior metallurgical engineer for the process development section at the new General Motors Technical Center in Detroit.

Ray E. Huffaker, formerly employed at the Ladish Co. plant in Cudahy, Wis., has been transferred to the new Ladish Pacific Div. plant in Los Angeles as a metallurgist.

Gilbert Bourcier, a recent graduate of the University of Wisconsin, is now employed as a metallurgist in the methods department of Revere Copper & Brass, Inc., Chicago.

Digests of ASM Convention Papers

Strengthening Stainless by Cold Work*

COLD working and warm working are recognized methods for improving the properties of metals and alloys at both low and high temperatures. Warm working is often incorporated into the manufacturing practice for high alloys which might otherwise be too weak for satisfactory operation.

The amenability of various stainless steel compositions to strengthening by cold or warm work is not too well known. The recrystallization temperature is probably one of the best measures of useful work hardening for high-temperature applications. This suggests that the presence of ferrite in an otherwise austenitic structure may be undesirable.

The present study was conducted on Type 347 columbium-stabilized stainless steel which was hot forged to ⅞-in. rounds at a maximum of 2200° F., then solution treated to 2000° F. for 1 hr. and water quenched. To determine the recrystallization parameters sections were cold swaged to various degrees, providing reductions in area ranging from 10 through 80%. Room-temperature tensile tests and creep-rupture tests at 1200, 1300 and 1500° F. were performed on the specimens that had been cold worked.

The results indicated that the recrystallization temperature in solution treated and cold worked Type 347 stainless steel may be as much as 200° F. lower during creep-rupture than in static tests. Useful high-temperature strengthening in creep-rupture can be achieved through cold work or warm work under the following conditions:

1. At 1200° F., up to 30% cold reduction yields improvement up to at least 1000 hr.
2. At 1300° F., up to 10% cold reduction for a 1000-hr. life and over 30% for a life of 1 hr. or less.
3. At 1500° F., up to 20% cold reduction for 1-hr. life. Avoid cold work for longer rupture life; the solution treated condition is best.
4. At 1100° F. and lower, it appears that significant improvements can be achieved for long-time use with cold work up to 30% or more.

H. J. ELMENDORF

*Digest of "Creep-Rupture Properties of Cold Worked Type 347 Stainless Steel", by N. J. Grant, Albert G. Bucklin and Warren Rowland, © 1955 Preprint 2.

Heat Treatability of a Titanium Alloy*

THE titanium alloy with 6% aluminum and 4% vanadium developed at Armour Research Foundation is currently one of the most popular commercial compositions and is being used in quantity in ordnance, airframe, and aircraft engine applications. In this investigation, the authors studied the heat treatment, stress stability, section-size effect, elevated-temperature tensile properties, and fatigue properties of this alloy as wrought from production ingots and heat treated.

The ingots were made from titanium sponge (140 Brinell hardness) in two analyses, (*a*) 6.26 Al, 4.13 V, 0.102 Fe, 0.013 N, 0.021 C and 0.006 H, and (*b*) 6.09 Al, 4.06 V, 0.147 Fe, 0.013 N, 0.015 C, and 0.004 H. All data except in the section-size study were derived from material rolled to 0.550 in. round, using a 30% reduction in area following the final reheat. A preheating temperature of 1700° F. was employed except for the study of rolling temperature effects.

Tensile tests were run on 0.250-in. diameter, specimens, 1-in. gage length, tested at head speeds of 0.05 in. per min., and 0.2% offset yield strengths were obtained using an O. S. Peters Microformer extensometer. Fatigue testing was carried out at 10,000 rpm. on R. R. Moore rotating-beam machines.

The alloy was shown to have a wide range of hot working temperatures. Varying the working temperature between 1400 and 1750° F. had little effect on the mechanical properties resulting from any subsequent heat treatment.

The data illustrate that moderately high strength levels accompanied by good ductilities can be obtained by duplex heat treatments. Tensile strength ranged from 140,000 to 175,000 psi. and yield strength from 100,000 to 165,000 psi., using solution treatments from 1550 to 1750° F. followed by aging at 900 to 1000° F. Slow cooling from the solution treatment temperature resulted in strengths as low as 130,000 psi.

A solution treatment at 1550° F. resulted in a minimum yield-tensile ratio of 0.7. In this soft, low-yield condition, the alloy offers the advantages of good machinability and excellent low-temperature formability. Subsequent aging may then be employed to increase the strength to maximum levels.

Yield strengths of 130,000 psi. may be obtained in sections up to 3-in., and 140,000 psi. in sections up to 1½-in., both with ductility values of about 20% elongation and 50% reduction in area. At some sacrifice in ductility, higher strengths could be obtained in the larger sections by aging at lower temperatures.

The alloy was stable under conditions of 50,000 psi. for 200 hr. up to 800° F. Under these conditions, total deformation was less than 1% when given a duplex heat treatment — 1750° F. for 1 hr., water quench, 1000° F. for 24 hr. With this treatment, the alloy had a tensile strength of 115,000 psi. and yield strength of 97,000 psi. at 800° F.

Endurance strength was also improved (endurance ratios sometimes greater than 0.55) with the duplex heat treatment.

R. L. FOLKMAN

*Digest of "Investigation of the Heat Treatability of the 6% Aluminum, 4% Vanadium, Titanium-Base Alloy, by R. G. Sherman and H. D. Kessler, © 1955 Preprint 35.



J-M BLAZECRETE cuts refractory maintenance costs...

That's why it pays you to use this hydraulic-setting refractory for temperatures to 3000F

Blazecrete* materially reduces labor costs for refractory maintenance. This hydraulic-setting refractory saves time in building and repairing linings for high-temperature equipment.

For troweling, just mix Blazecrete with water as you'd mix ordinary concrete . . . then slap-trowel it in place. When gunned, it adheres readily with a minimum of rebound loss. Either way, Blazecrete goes on fast, without laborious ramming or tamping. And Blazecrete linings *last.*

Three types of hydraulic-setting Blazecrete are available. All harden on air curing, do not require prefiring. They are furnished as a dry mix—can be stored safely for use as needed.

3X BLAZECRETE—For temperatures through 3000F. Unusually effective for heavy patching, especially where brickwork is spalled or deeply eroded. Excellent for forge furnace linings, lime kilns, burner blocks, soaking pits, and industrial boilers.

STANDARD BLAZECRETE—For temperatures through 2400F. Makes repair work easier and less costly. Can be used by boiler manufacturers to replace fire clay tile in wall construction. Suitable for use in combination with 3X Blazecrete and L. W. Blazecrete.

L. W. BLAZECRETE—For temperatures through 2000F. An insulating refractory . . . light in weight, low in thermal conductivity. Adaptable and economical for many other applications.

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BUILDS BETTER REFRACTORY LININGS

Torsional Properties of Steel*

A REVIEW of previously published reports indicated to the authors that endurance limit values might be approximated from torsion test data. If such a relationship exists it would offer a substitute testing procedure with a commensurate saving in time and expense.

Six medium-carbon alloy steels of the 2300, 4000 (two steels), 4100, 4300 and 5100 series were selected and each of the series heat treated to seven hardness levels ranging from approximately C-29 to C-65. Torsion test bars were very carefully machined, heat treated and finish ground to close tolerances. While torsional yield strengths were the main objective, all bars were twisted to failure and three characteristic types of fracture were observed. Type A fractures exhibited a bright surface and sheared cleanly on a plane perpendicular to the axis of the specimen. Type B fractures resulted when the specimens shattered in a number of pieces along irregular surfaces with a dull appearance. However, Type B fractures did contain some bright surfaces in planes either parallel or perpendicular to the axis. Type C fractures were found along planes at 45° to the axis. There was no shattering but the surface of the breaks was dull.

All failures within the straight-line portion of the torsion yield strength-hardness curves had Type A fractures perpendicular to the specimen axis. Above the straight-line portions of the curves the fractures were either Type B or Type C. At the highest hardness all steels showed Type C fractures.

The torsion yield strength was compared graphically to endurance limit data taken from a prior publication by Garwood, Surburg and Erickson. There was a similarity between the two sets of data in that there is the same straight-line relationship dependent upon a limiting hardness level. The beginning of instability or scatter occurs at lower hardness numbers for the endurance

(Continued on p. 166)

*Digest of "Relationship of Torsional Yield Strength to Endurance Limit and Hardness", by S. T. Ross, R. P. Sernka and W. E. Jominy, © 1955 Preprint 10.



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- **Polished bright, yellow or blue.**
- **With square, round or dressed edges.**
- **Wide range of sizes in stock—**
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Torsional Properties . . .

limit than for torsion yield strength.

Electron micrographs indicated that finely divided percarbides are present in the tempered martensite in the range of instability of the yield strength-hardness relationship. It was also found that percarbide films outlined the martensite needles tempered for 1 hr. or more in the 200 to 350° F. range. Above 450° F. these films were supplanted by elongated and discontinuous cementite particles. There were no microstructural differences for the various steels tempered under the same conditions of time and temperature.

H. J. ELMENDORF

Hydrogen Absorption by Titanium*

HYDROGEN contamination severely affects the use of titanium and titanium alloys. Much of the hydrogen is absorbed during pickling and the authors have studied the effects of time and temperature on hydrogen absorption in sodium hydride, Virgo and acid pickling baths. Data on weight loss and hydrogen absorption were obtained by exposing specimens for various times over temperature ranges of pickling which might be encountered in manufacturing operations. Commercially pure titanium (A-55) and Ti-8 Mn (C-110 M) sheet and bar specimens were used.

The Virgo-treated materials showed virtually no hydrogen pickup after descaling at 850, 930 and 1000° F., but the surfaces were covered with shallow pits and were not bright.

The materials descaled in sodium hydride absorbed a significant amount of hydrogen in all conditions. The A-55 titanium picked up less hydrogen than the C-110 M alloy and ¼-in. rod picked up less hydrogen than the 0.040-in. sheet. Increasing the descaling time and temperature increased hydrogen absorption, except for the tempera-

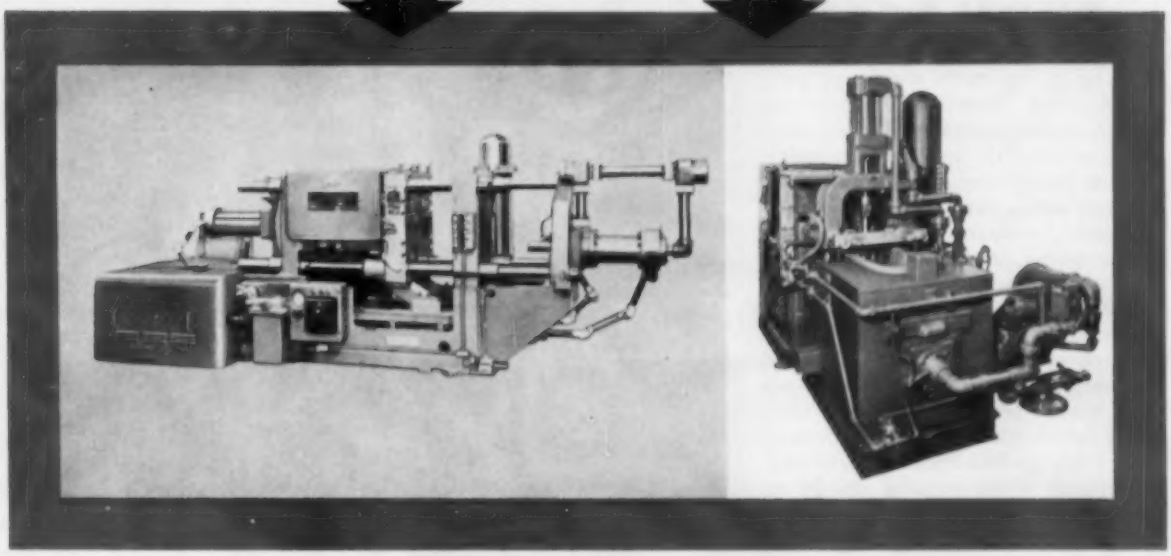
(Continued on p. 168)

*Digest of "Hydrogen Contamination in Descaling and Acid Picking of Titanium", by G. A. Lenning, C. M. Craighead, and R. I. Jaffee, 1955 Preprint 33.

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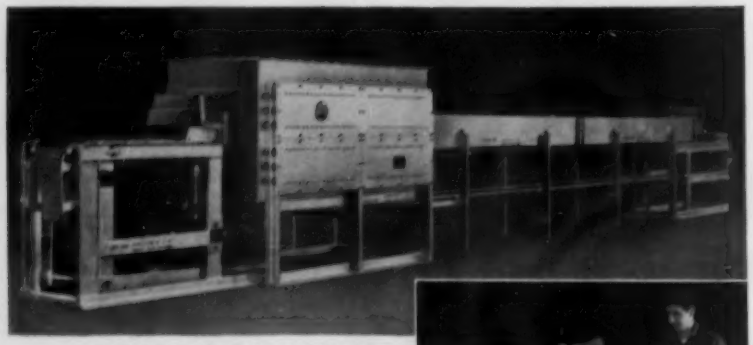
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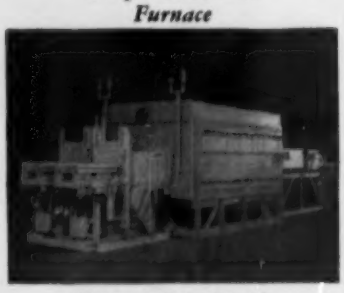
Photograph shows Harper Electric Mesh Belt Type Furnace being used for continuous bright brazing in hydrogen atmospheres. Material is fed to charging station by conveyor. Mesh belt woven from heat resisting alloy wire carries charge through hot zone and cooling chamber to furnace exit. Stationary drum permits charge to drop into tote pans or be automatically transferred to next operation by conveyor.

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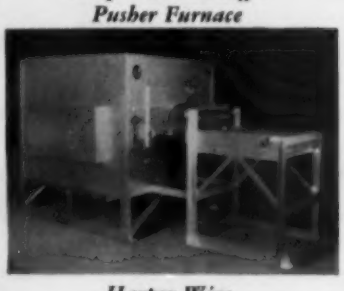
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Hydrogen in Ti . . .

ture rise from 700 to 800° F. No explanation is evident for this anomaly. Generally, the sodium hydride-descaled material was lustrous except at 900° F. when there was shallow pitting. The condition of the surface (whether scaled or shot-blasted) did not appreciably affect the hydrogen absorption rate at the times and temperatures tested.

Acid pickling resulted in considerable hydrogen pickup for the scale-free C-110 M alloy when pickled at 120° F. for 15 min. or 160° F. for 10 min. It picked up less when the surface scale was left on. The scale apparently acts as a barrier to further hydrogen absorption.

The amount of hydrogen absorbed appears to be a function of alloy composition, ratio of surface area to mass and the time and temperature of descaling. Sheet material absorbs more hydrogen than rod. The alpha A-55 titanium absorbs less hydrogen than does the alpha-beta C-110 M alloy.

In summary, Virgo-descaled material absorbs virtually no hydrogen but loses luster, while the sodium hydride-descaled material absorbs considerable hydrogen but retains luster. Pickling in a 10% nitric, 2% hydrofluoric acid bath results in appreciably more hydrogen absorption in the C-110 M alloy than in the A-55 titanium.

G. A. FRITZLEN

Effect on Surfaces of Metal Removal*

THE effects of metal removal and heat treatment on and near the surfaces of hardened steel parts are difficult to evaluate since they cannot generally be completely controlled. For example, it is accepted practice to grind off several thousandths of an inch to remove the decarburized layer on a hardened steel part; however, grinding in itself may introduce additional surface effects. Thus, a finished hard-

(Continued on p. 170)

*Digest of "Some Effects of Metal Removal and Heat Treatment on the Surfaces of Hardened Steels", by Karl E. Beu and Donald P. Koistinen, © 1955 Preprint 28.

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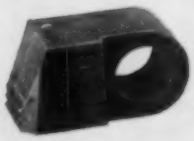
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Metal Removal . . .

ened part may have nonuniform phase or stress distributions near the surface as a result of heat treatment, finishing operations, or both. These nonuniformities may, in turn, have a profound effect on the physical properties of hardened steel parts.

The effects of heat treatment and metal removal have been previously studied by measuring surface gradients of microhardness, carbon content, residual stress and retained austenite. In the present work retained austenite and residual stress measurements were made using X-ray diffraction techniques.

A series of hardened plain carbon steels with 5 to 30% retained austenite was studied to determine the utility of metallographic polishing as a metal removal standard, and the validity of mechanically polished and etched surfaces as being representative of these samples. Reference behavior was established by study of samples in which metal was removed electrolytically.

It was found that metal removed with a standard metallographic polishing sequence affected the retained austenite content significantly below the final polished and etched surfaces, and left large compressive stresses in the surfaces.

As a more drastic method of metal removal, some experiments were carried out on a belt sander. A sample of hardened S.A.E. 1095 steel was used, and metal was removed using fast, slow, dry and wet sanding, as well as electrolytic removal techniques. The sander was chosen in preference to a grinder because it was possible to maintain uniform hand pressure of the sample on the sanding belt from one experiment to the next, thereby minimizing the effect of this variable on these experiments.

It was found that metal removed using a belt sander increased the austenite content of the surface if the metal was removed rapidly, and decreased the austenite content of the surface if the metal was removed slowly. In either instance, large compressive stresses were left in the surface. After either mechanical metallographic polishing or belt sanding, the compressive stresses could be reduced essentially to zero

(Continued on p. 172)

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Metal Removal . . .

by removing about 0.005 in. of the surface electrolytically.

In order to study the effects of metal removal on austenite content hardened steel samples were prepared with uniform austenite contents from the immediate surface to the interior. To accomplish this, the surfaces were protected from the atmosphere by a copper plate about 0.002 in. thick. Substantially thinner or thicker copper plate did not protect effectively.

Samples of 1095 steel prepared with one side protected were studied after heating in a slightly decarburizing atmosphere at 1600° F. for times up to 2 hr. The extent of decarburization was studied by means of austenite content, austenite and martensite lattice parameters, and chemical carbon measurements with depth. The results are presented in a series of graphs.

G. V. Smith

Fatigue and Anisotrophy in Copper*

Previous work has provided evidence that wrought single-phase alloys and metals of moderately high purity may exhibit a pronounced anisotropy in fracturing. This is postulated to be a result of microcracks or crack-like flaws aligned parallel to the axis of the wrought bar of the test material. By twisting a tensile bar and introducing a predetermined amount of shear strain at the surface of the bar, tensile fracture occurs by separation across a helical surface after little reduction in cross-sectional area and at a low value of the average true fracture stress. However, tensile fracture following prestraining by equal amounts of forward and reverse torsion is of the ductile type. This torsional prestraining technique was used by the authors in studying the anisotropic behavior of copper in fatigue.

Cold drawn, electrolytic tough-pitch copper was used in the investigation. Torsion specimens were ma-

(Continued on p. 174)

*Digest of "Fatigue and Anisotropy in Copper", by M. L. Ebner and W. A. Backofer, © 1955 Preprint 22.

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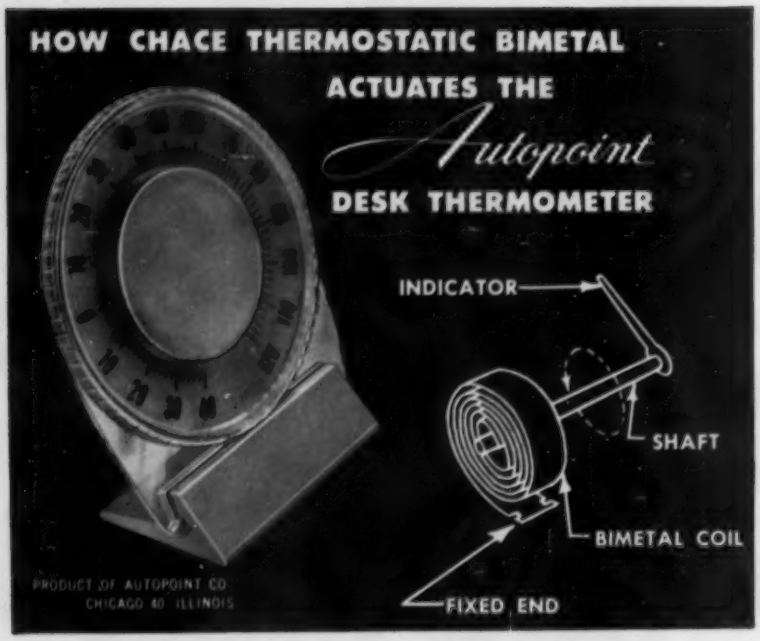
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Fatigue in Copper . . .

chined and annealed. One set of specimens was subsequently twisted to produce a shear strain of 5 at the surface of the minimum section of the fatigue specimen. Another set was twisted to a shear strain of 2.5 and then completely untwisted. From these samples fatigue bars were machined and tested on a resonance-type fatigue machine. Five specimens from each of the two prestrained sets were tested in alternating bending at each stress level. Stresses employed were 20,000, 25,000, 30,000, and 35,000 psi.

The authors postulate that as a result of a unidirectional twisting the microcrack or crack-like flaws will approach an alignment at right angles to the axis of the fatigue specimen, whereas the specimens that were twisted and untwisted should have the flaws aligned parallel to the axis of the specimen. The latter should possess a greater fatigue life than the former.

The fatigue data, plotted as a typical S-N curve, showed that the endurance limit of the unidirectionally prestrained samples was lower than those samples which were prestrained by reversing.

The type of fractures resulting from fatigue testing was different depending upon the manner of prestraining. Those which were twisted in a unidirectional manner failed by the crack growing inward from the surface and failed in a helical manner. Those samples which were given a reverse twist failed perpendicularly to the specimen axis.

Charts illustrating crack growth from failure onward showed that the slope of the twisted sample was almost three times greater than the slope for the twisted and untwisted specimens. This is a further indication that the microcrack orientation contributes to the growth of a fatigue crack.

The authors conclude that commercial copper can be highly anisotropic with respect to its mechanical behavior in fatigue. Further, as a result of microcrack orientation, specimens twisted in one direction only (*a*) failed after fewer cycles of stress, (*b*) developed a helical, fibrous-appearing fracture rather than a fracture normal to the specimen

(Continued on p. 176)



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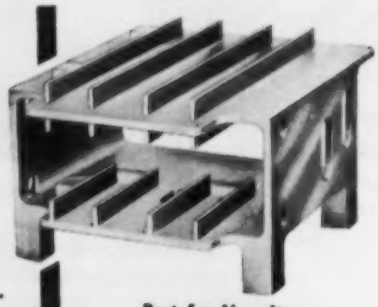
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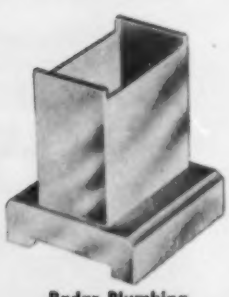
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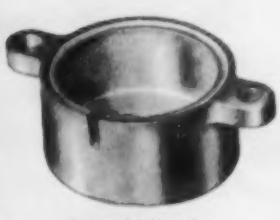
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Fatigue in Copper . . .

axis, and (*c*) exhibited much more rapid crack propagation. In samples prestrained by twisting and untwisting the microcracks, being oriented parallel to the axis, do not contribute directly to the onset of failure.

R. D. CHAPMAN

Deformation of Beryllium*

COMPRESSION tests at room temperature, 300 and 500° C. were conducted on single crystals of beryllium (99.8% pure) of various orientations. The specimens, about ½-in. cubes, were cut from two coarse-grained ingots and annealed in vacuum for an hour at 1000° C.

The compression unit consisted of a cylindrical hardened steel plunger, an anvil and a container. One end of the plunger matched the compression plate of the testing machine, while the other was highly polished, as was the opposing surface of the anvil. Compressions were carried out in a series of steps with frequent lubrication. For the runs at elevated temperatures, the compression unit was put in a nichrome-wound furnace whose temperature was controlled. At room temperature and 300° C., Silicone DC 200 oil was used for lubrication, and at 500° C. Houghton's Mar-Temp salt was used. These not only lubricated the compression surfaces but also protected the specimens from exposure to air.

Strain was measured by a microformer-type extensometer attached across the stationary and movable parts of the testing machine. A lever combination connected to the plunger of the microformer provided for several different magnifications of the head movement. Throughout the tests a constant rate of head movement of 0.002 in. per min. was maintained.

The only mechanisms operating at room temperature, 300 and 500° C. were: slip on the basal and $(10\bar{1}0)$ planes of the original material, twin-

(Continued on p. 178)

*Digest of "Deformation of Beryllium Single Crystals at 25 to 500° C.", by H. T. Lee and R. M. Brick, © 1955 Preprint 13.



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	YME million psi	Tensile Strength psi	d (lbs./cu. in.)	$\frac{YME}{d} \times 10^6$	$\frac{TS}{d} \times 10^3$
Magnesium alloy	6.5	39,000	.0645	101	600
Aluminum alloy	10.3	82,000	.101	102	810
Stainless Steel (304)	26.	185,000	.286	90	64
Titanium metal alloy	16.	150,000	.163	98	920
Kentanium (the titanium-carbide alloy)	50.	135,000	.228	219	592

Typical Applications for Kentanium

Because of these unique properties, Kentanium is now in every engineer's mind for such applications as gas turbine blades, vane rings, impellers; diesel engine valve seats; hot rod mill guide inserts; bearings; bushings in contact with liquid metals; flame tubes; thermocouple protection tubes; anvils for spot welding; pressure sleeves; hot hardness tester balls. Kentanium can be supplied in tubes, rods, bars and highly complex shapes.

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Beryllium . . .

ning on the $(10\bar{1}2)$ planes, slip on the basal plane of twinned regions, and cleavages along (0001) and $(11\bar{2}0)$ planes. The relative prevalence of these several mechanisms was classified into five groups of orientation. Secondary deformation features such as deformation bands and kink bands were also observed when the strain was inhomogeneous. A peculiar type of band resulting from the change of length of slip direction from plane to plane was found in some specimens with particular orientations. Basal slip lines generally were found to be straight at room temperature and 300° C. but $(10\bar{1}0)$ slip lines always appeared wavy and forked at all temperatures.

In a second part of the paper, atomic movements in mechanical twinning of metals are analyzed and factors affecting twinning evaluated.

G. V. SMITH

Low-Temperature Deformation of Mg*

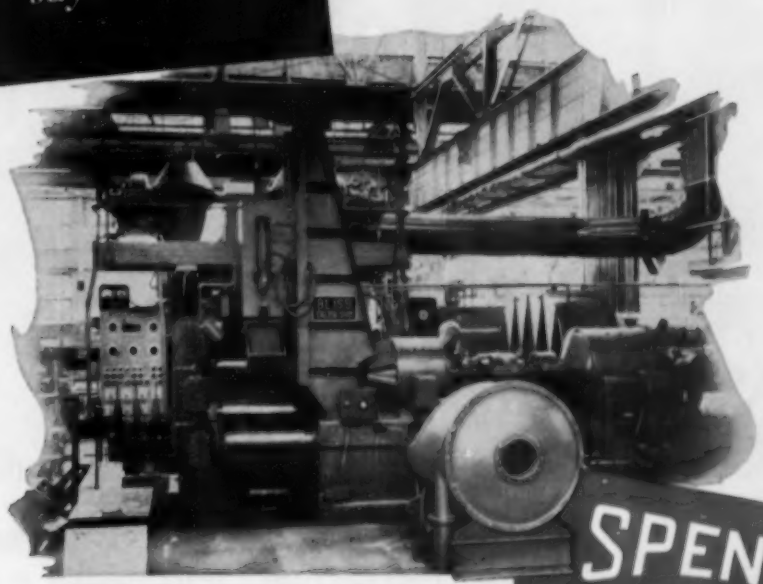
DETAILED studies of deformation and fracturing characteristics of large-grained polycrystalline aggregates of magnesium at atmospheric temperature have been presented in an earlier report. These studies have been extended to subatmospheric temperatures down to the boiling point of nitrogen, –320° F. Special emphasis was placed on possible differences in mechanisms of deformation and fracturing obtained with a decrease in test temperature.

In the earlier investigation it was shown that polycrystalline aggregates of magnesium slip exclusively on the (0001) plane and in the $<2\bar{1}10>$ or equivalent, direction at atmospheric temperature. Such basal slip was also found to be operative at –110 and –320° F. In fact, no significant differences were detected in either the spacing of the slip bands or in the extent of basal

(Continued on p. 180)

*Digest of "Deformation and Fracture Mechanisms of Polycrystalline Magnesium at Low Temperatures", by F. E. Hauser, P. R. Landon, and J. E. Dorn, © 1955 Preprint 15.

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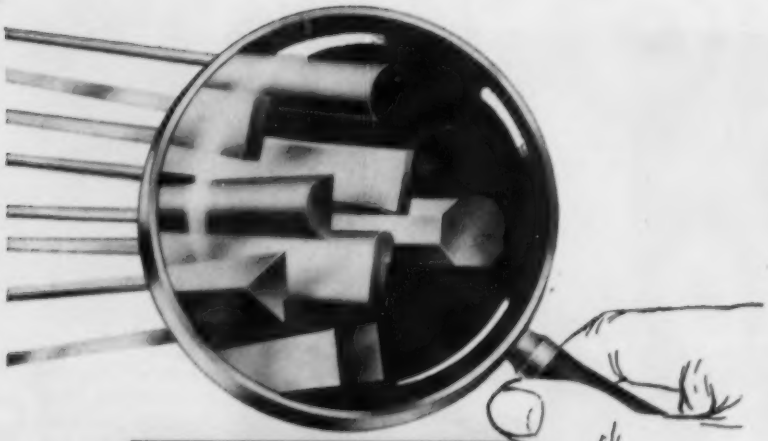
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Deformation of Mg . . .

slip as a function of temperature.

While grain-boundary shearing is quite prevalent at atmospheric temperature, it is rare at –320° F. As grain-boundary shearing decreases with a decrease in temperature, the amount of prismatic slip of the form $\{1100\}$, $\langle 2\bar{1}\bar{1}0\rangle$ increases. These and other related observations suggest that highly localized stresses are relieved by grain-boundary shearing at atmospheric temperature whereas they cause prismatic slip at lower temperatures. Pencil slip occurs at lower temperatures by conjugate mechanisms on planes $\{0001\}$ and $\{1\bar{1}00\}$ along their common $\langle 2\bar{1}\bar{1}0\rangle$ direction.

Twinning takes placed by shear parallel to $\{10\bar{1}2\}$ planes in the $\langle 10\bar{1}1\rangle$ direction from room temperature to –320° F. Fracturing occurs by intergranular and transcrystalline modes in the same temperature range. The mechanism of transcrystalline fracture was not identifiable as cleavage along the $\{0001\}$ planes. J. L. Gregg

Rolling Textures in Tantalum*

A review of past work shows that the textures of body-centered cubic metals are strikingly similar. Cold rolled textures are consistent and can usually be described by the $\{100\}$ $\langle 011\rangle$ orientation with a large spread (40 to 60°) about the rolling direction in the plane of the sheet. Much smaller spreads are observed around the cross direction as an axis. Alternate descriptions of this texture can be made based on the three "ideal" orientations $\{100\}$ $\langle 011\rangle$, $\{112\}$ $\langle 011\rangle$, and $\{111\}$ $\langle 112\rangle$. For recrystallized body-centered cubic metals the most frequent components reported are the $\{111\}$ $\langle 112\rangle$ orientation and a split $\{100\}$ $\langle 011\rangle$, each component of which is rotated (15 to 25°) from the rolling direction about the pole of the rolling plane.

The present study on tantalum

(Continued on p. 182)

*Digest of "Rolling Textures in Tantalum", by J. W. Pugh and W. R. Hibbard, Jr., © 1955 Preprint 39.

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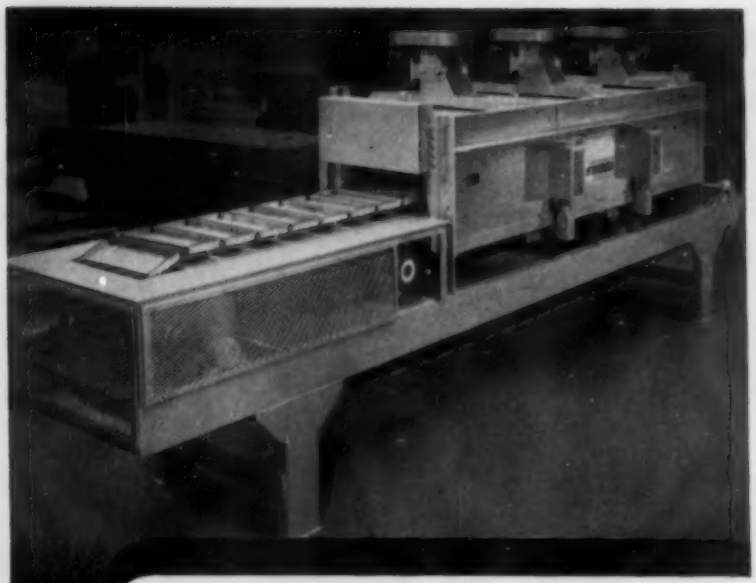
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Rolling Tantalum . . .

(99% purity) was made on strip cold rolled 95% to 0.010 in., recrystallized, then further cold rolled 95% to 0.0005 in. in a Sendzimir mill. Samples for X-ray diffraction study were cut from this strip and annealed at 2010, 2190, 2370, 2550 and 4530° F.

Pole figures were made with an integrating pole figure goniometer permitting continuous rotation about a perpendicular to the sheet as an axis and a 5° incremental rotation about a direction parallel to the plane of the sheet. The specimen was raised and lowered a distance of 1 in. at a rate of one cycle per second so that a large area could be covered. Diffracted X-rays were detected by a stationary Geiger-counter detector. Intensities were calibrated by comparison with diffraction from a random sample. Molybdenum K-alpha radiation was used with a zirconium filter.

The pole figures revealed that the cold rolled texture of tantalum is similar to those previously published for other body-centered cubic metals. This texture can be interpreted in terms of the orientations {100} <011>, {112} <011>, and {111} <112>. The last two are double textures which are disposed to cause symmetry in the cross direction and the rolling direction respectively. The intensity peaks associated with {112} <011> are not all centered precisely on this orientation. The component having the highest intensity is displaced about 12° from {112} and corresponds approximately to the orientation {223} <011>. Description of the cold rolled texture in terms of a single spread about the rolling direction as an axis is not satisfactory in this case in view of the discrete intensity peaks associated with these other orientations.

The pole figures for material annealed at 2010, 2190 and 2370° F. show a gradual alteration in the cold rolled texture to that of the recrystallized texture. Full recrystallization was reached on annealing at 2550° F. The texture is attributable only to the {111} <112> orientation. The texture for material annealed at 4530° F. was like that after annealing at 2550° F. except that it was considerably sharper. The sequence of changes during annealing was: sharpening of the texture near {112}

<110> during recovery; strengthening of the {111} <112> texture during recrystallization; monopoly of the texture by the single orientation {111} <112> texture after recrystallization; and finally sharpening of the {111} <112> texture after grain growth. The sequence suggests that recrystallization takes place in tantalum by a growth selectivity mechanism. The {111} <112> orientation which was present in the cold rolled metal appears to have grown at the expense of other orientations. This contrasts with the behavior of silicon iron in which the {111} <112> component recrystallizes to {110} <001> orientation. This latter behavior suggests oriented nucleation.

Analysis by the Pickus-Mathewson criterion indicates that slip takes place in tantalum on {110} planes.

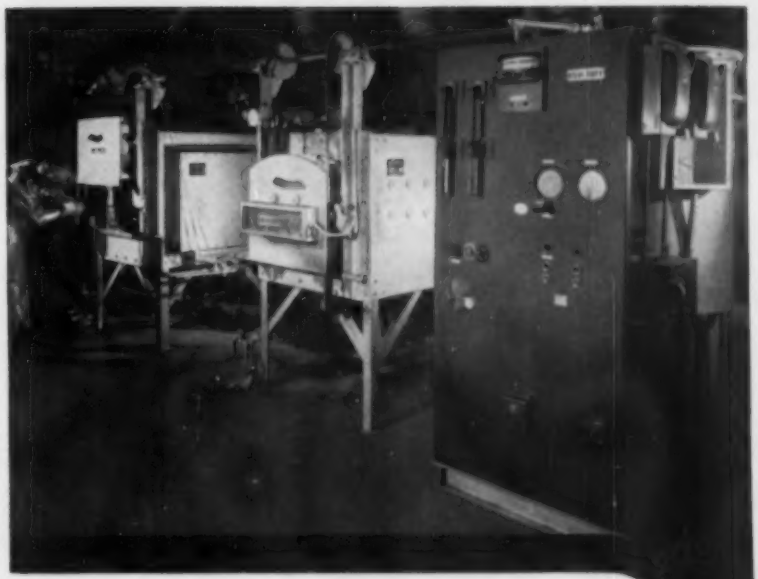
G. V. Smith

Graphitization of Steel*

Work previously reported by G. V. Smith has shown that heating bars of a eutectoid carbon steel in an atmosphere of gaseous nitrogen caused a surface rim in which the carbide phase was resistant to graphitization during the heating of an initially martensitic structure for ten days at 1200° F. This discovery led the authors to conclude that it might be possible to prevent graphitization which sporadically appears in the processing of commercial articles from cold rolled, high-carbon strip steel. In previous work they had also shown that a martensitic structure is most susceptible to graphitization when heated at 1200° F. under vacuum. As a result, they selected eight samples of steel analyzing approximately 1.25 C, 0.40 Mn, 0.20 Si, 0.30 Cr, 0.007 to 0.015% Al and 0.004 to 0.006% N. The samples were heated in helium or nitrogen for 6 hr. at 1900° F. and quenched in brine to form a martensitic microstructure.

A supplementary investigation included heating another set of samples in hydrogen for 2 hr. and quenching to test previously reported observations that hydrogen inhibits graphitization. The helium and nitro-

*Digest of "Inhibition by Nitrogen of Graphitization of Steel", by G. V. Smith and B. W. Royle, ⓒ 1955 Preprint 17.



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Graphitization . . .

gen were purified by passing over heated copper and then through activated alumina. The hydrogen was first purified in the same way and then passed over heated magnesium turnings. After quenching, the samples were separately sealed in Vycor containers under vacuum and heated for ten days at 1200° F.

With one exception, the quantity of the graphite formed in the samples heated in helium was roughly proportional to the aluminum content of the steel. None of the material heated in nitrogen was graphitized with the exception of one which showed a slight trace. Chemical analysis for nitrogen showed that it had been increased to about 0.012 to 0.014% from the original 0.005%.

The samples heated in hydrogen contained more graphite than those heated in helium. The quantity of graphite again was roughly proportional to the aluminum content. Chemical analysis of the steels heated in hydrogen indicated that the increase in susceptibility to graphitization was due to a decrease in the nitrogen content from 0.005 to 0.003%.

Although the graphitizing treatment used in this investigation does not simulate commercial practice, it is the severest test possible without plastic deformation of the material. The authors believe that the steels resistant to graphitization in their experiments would not graphitize during commercial processing.

R. D. CHAPMAN

High-Nitrogen Stainless Steel*

ORDINARILY iron-chromium-carbon alloys are ferritic. However, with sufficient nitrogen added, the higher chromium (above about 22%) alloys can be made partially but not completely austenitic. If the higher chromium alloys contain up to 1% carbon, the amount of nitrogen that can be retained is greatly increased.

(Continued on p. 186)

*Digest of "Austenitic Fe-Cr-C-N Stainless Steels", by G. F. Tisinai, J. K. Stanley and C. H. Samans, 1955 Preprint 7.

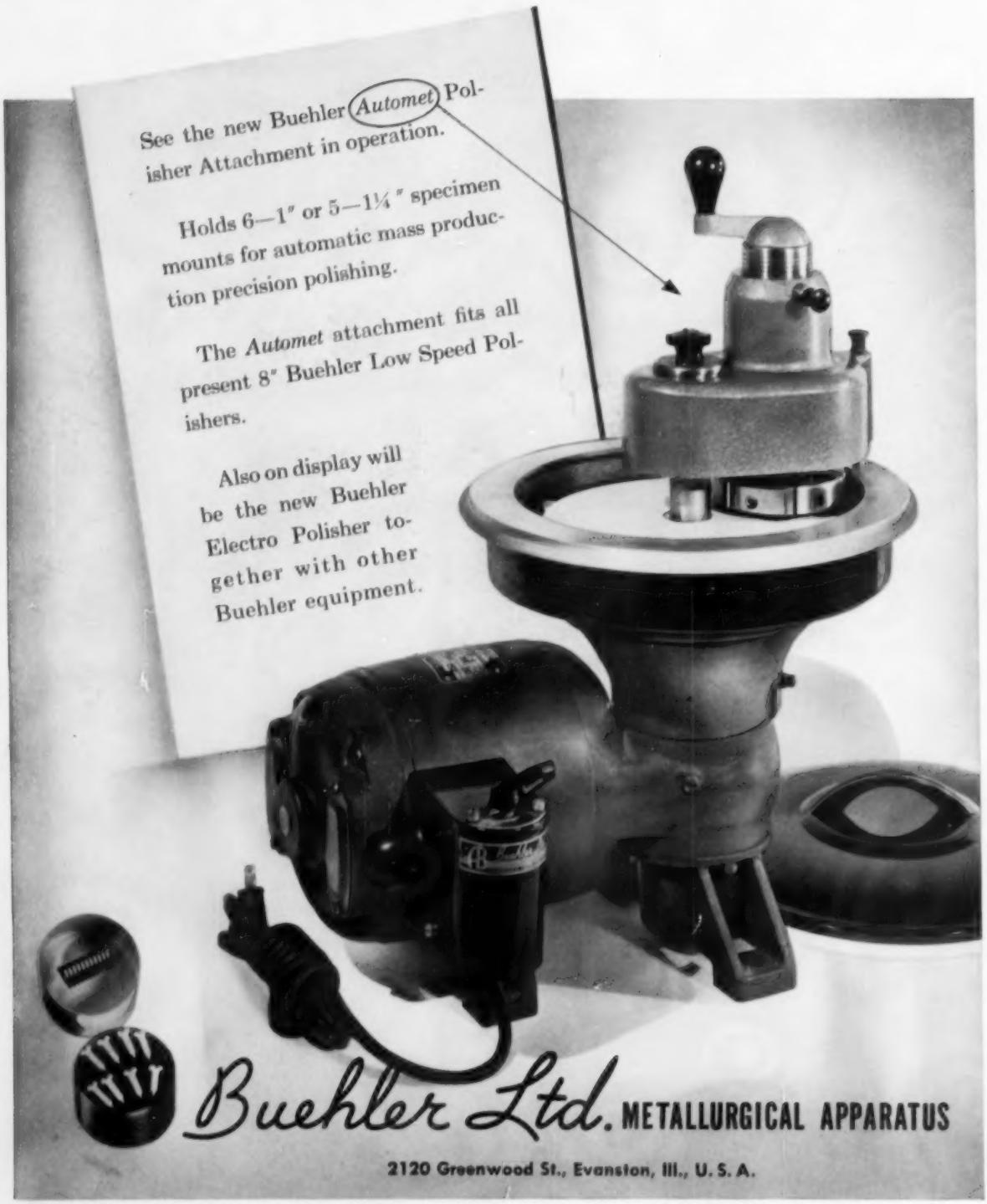


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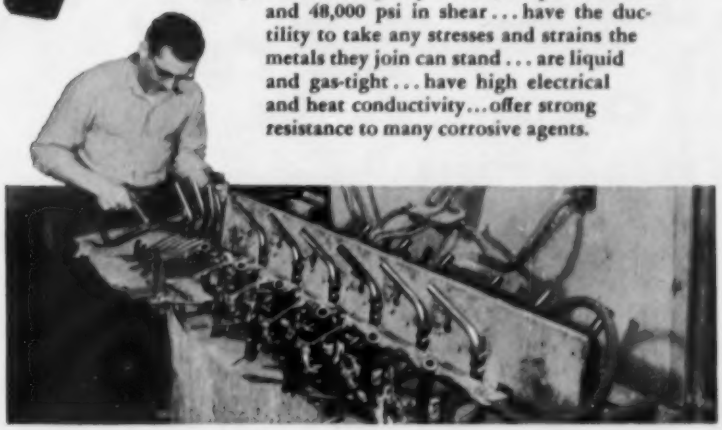
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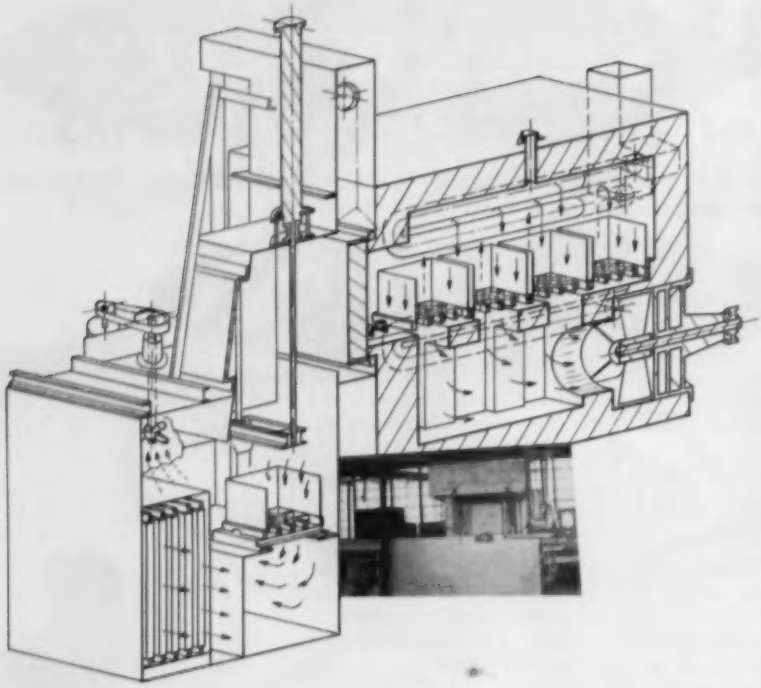
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High-N Stainless . . .

The high carbon and nitrogen appear to act synergistically, so that completely austenitic alloys result.

The desired alloys were made by casting, by powder metallurgy and by nitrogenization (solid-gas reaction). In casting, the addition of more nitrogen than 1/75 to 1/100 of the chromium content results in considerable loss of nitrogen during solidification. However, if the carbon content of the melt is increased to 1%, loss of nitrogen is minimized or prevented so that alloys containing as much as 0.7% nitrogen can be cast directly. Some typical austenitic compositions that have been made using ordinary casting techniques are 21% Cr, 0.3 C, 0.3 N; 24 Cr, 0.4 C, 0.4 N; and 27 Cr, 0.5 C, and 0.5 N. Although the austenitic grain size is quite large in cast alloys, it can be refined for control of mechanical properties by decomposing the alloys to ferrite, carbides and nitrides, and then re-austenitizing for short periods of time at 2200 to 2300° F.

Nitrogen was added to iron-chromium-carbon alloys by heating in dry nitrogen at temperatures up to 2300° F. By nitrogenization, completely austenitic structures can be obtained with lower carbon contents than are required for the casting technique. The final method of obtaining alloys was by cold pressing and sintering mixtures of powdered iron, chromium, iron carbide and chromium nitride.

Alloys prepared from powders were used to determine the phase relationships at 2200° F. in the Fe-Cr-C-N system. As the chromium content increases from 21 to 30%, the single-phase region of austenite decreases and it disappears in alloys containing 33% chromium.

Like Hadfield manganese steels, the austenitic Fe-Cr-C-N alloys exhibit extreme work hardening. This effect is reflected in their resistance to cutting, and to deformation in a tensile test. Even though the austenite shows a hardness value of only about C-20, it is virtually impossible to cut it with ordinary toolsteels. It can, however, be machined with carbide tools. When the alloys are decomposed to ferrite, carbides, and nitrides, they may be machined readily with ordinary cutting tools.

(Continued on p. 188)

Tool Steel Topics

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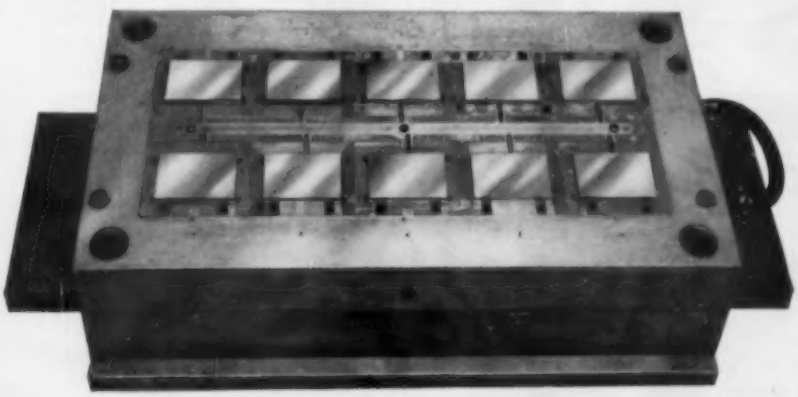
PLASTIC BOXES BY THE MILLIONS WITH Dies of BTR

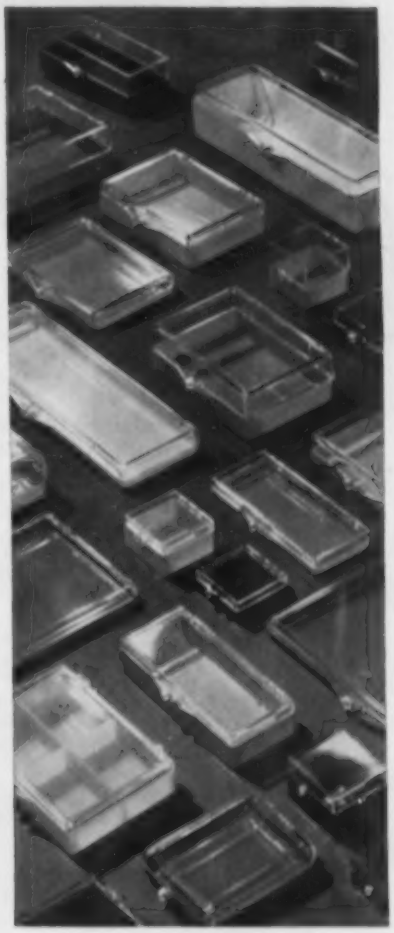
This die, made of BTR (Bethlehem Tool Room) tool steel, is typical of the dies used by Hake Manufacturing Co., Inc., Roanoke, Va., makers of plastic boxes. The die is used in injection molding of plastic parts of polystyrene, the BTR being used for the die-cavity, cores and runners.

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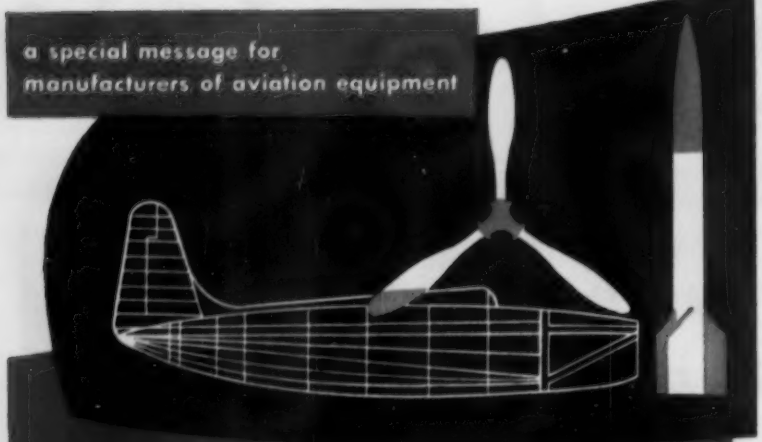


Billets Are Billets (Not Bars)

"Billets are billets" is a truism similar to "Pigs is pigs," and is just as appropriate. A tool steel billet is a semi-finished product intended for use by forging to desired size. It is definitely not intended to be used to make tools by machining, as is bar stock.

This distinction may seem like hair-splitting, particularly if you have already machined tools directly from billets (when the correct bar size was not available) without encountering trouble. Although trouble does not develop every time billets are used in this manner, machining still remains an incorrect procedure, and should always be avoided.

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In the tensile test very little localized necking occurs, even with reduction of area values of 50%. The tensile strength of an alloy containing 27 Cr, 0.5 C, and 0.7 N was 138,000 psi. and the yield strength 90,000 psi.

These alloys may be useful in corrosive environments (because of their high chromium contents) where strength and abrasion resistance are required. They may not be too useful for elevated-temperature service because they decompose to ferrite, carbides and nitrides above approximately 800° F.

J. L. Gregg

Effect of Tempering Temperature on Martensitic Stainless*

The effect of tempering temperatures from 300 to 1200° F. on stress-corrosion and hydrogen embrittlement is illustrated for the 12% Cr types of stainless steels – A.I.S.I. Types 410, 420, 422 and 416. The data are correlated with observed differences in microstructure.

Commercial heats of the above grades of steel were obtained in the form of rectangular bar stock. This material was annealed, austenitized at temperatures from 1800 to 1900° F. for 1 hr. and oil quenched. Individual specimens were tempered for 2 hr. in the range of 300 to 1200° F. Test specimens were machined, and following tempering were ground to flat bars, $0.500 \times 0.125 \times 4$ in., for both stress-corrosion and hydrogen embrittlement studies. The specimens were all subjected to a stress below the elastic limit by bending. The magnitude of the applied stress was measured both directly and indirectly with SR-4 strain gages.

For stress-corrosion studies the specimens in the test assembly were exposed to an atmosphere of 5% NaCl until failure occurred or until 75 days had elapsed without failure.

(Continued on p. 190)

*Digest of "Effect of Tempering Temperature on Stress-Corrosion Cracking and Hydrogen Embrittlement of Martensitic Stainless Steels", by Peter Lillys and A. E. Nehrenberg, ⓒ 1955 Preprint 30.



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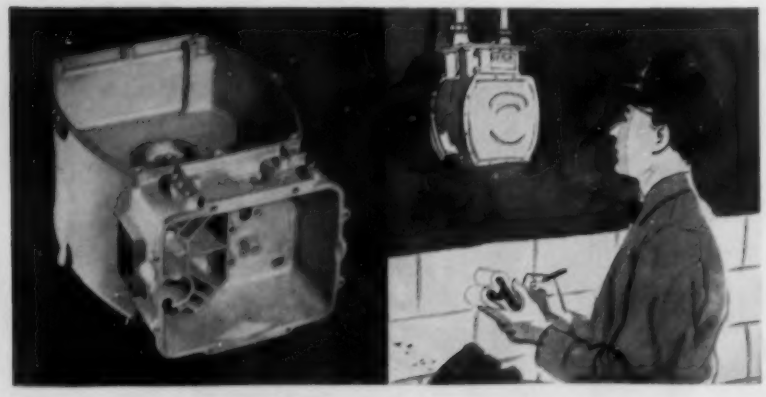
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For a detailed description of the Thompson Light Metals facilities which are available to you, send for your free copy of "Creative Castings." Just write to Dept. MPS, Light Metals Division, Thompson Products, Inc., 2269 Ashland Road, Cleveland 3, Ohio.

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Tempering Stainless . . .

A specimen was considered to have failed when visible cracking or actual failure was observed. Observations were made daily.

For hydrogen embrittlement studies, specimens prepared and stressed as above were immersed as a cathode in a cell solution of 0.1 normal sulphuric acid containing 3 mg. of arsenic per liter of solution. The potential across the cell was 3 volts with a current of 0.6 amp. The specimens were observed continuously in the cell and the time for failure by cracking was recorded. The maximum time of testing was 3 hr. if no failure occurred.

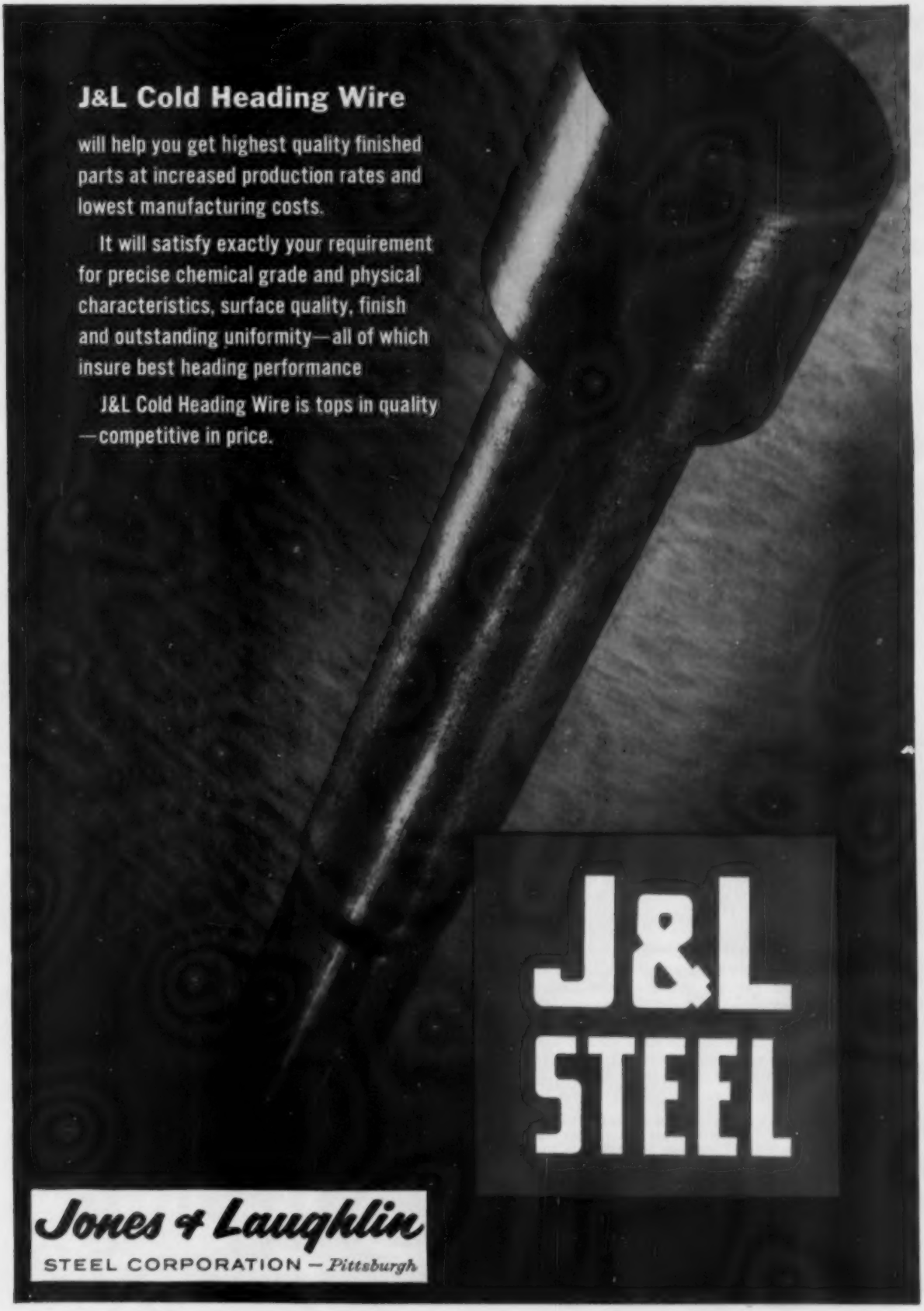
The data showed that for all the 12% Cr steels studied, stress-corrosion cracking was most likely to occur when a tempering temperature of 900° F. was employed. As quenched specimens, those tempered below 700° F. or above 1100° F. showed no evidence of stress-corrosion failure after 75 days exposure. The susceptibility of Type 410 steels in the tempering range of 800 to 1000° F. was greatly minimized by the presence of 5 to 10% delta ferrite in the microstructure. This beneficial effect of ferrite was also observed to a lesser degree in Types 422 and 436.

The cracking was observed to be intergranular with tempering temperatures of 950 to 1100° F. This was found to be associated with evidence of grain-boundary precipitation of carbides which occurred at a minimum temperature of 750° F. A 950° temper produced an almost continuous network of carbides. With tempering temperatures above 1150° F., the steels became immune to stress-corrosion cracking. Cracking at 900° F. was found to be both intergranular and transgranular. The reduction in stress-corrosion cracking as a result of the presence of ferrite was said to be the result of interrupting crack propagation and minimizing the amount of carbide precipitation at the prior austenite grain boundaries.

An experiment was conducted which indicated that hydrogen liberated by the corrosion process is not an important factor in the stress-corrosion cracking of the 12% Cr steels.

It is known that 12% Cr steels are

(Continued on p. 192)


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Tempering Stainless . . .

susceptible to hydrogen embrittlement. The data in this study of the effect of tempering temperatures on embrittlement of stressed samples revealed a lowered tendency for embrittlement at 500 and 900° F. Temperatures below 500° and between 500 and 900° F. resulted in faster failures.

No brittle failures were observed when tempering temperatures above 1050° F. were employed. Hydrogen embrittlement failures for temperatures below 800° were entirely transgranular. At 850 to 950° F., failures were intergranular and transgranular and at 1000° F. specimens failed only intergranularly.

The peculiar effect of tempering temperatures on the susceptibility of stressed 12% Cr steels to hydrogen embrittlement was related to the stages of tempering and the resulting microstructure. Dilatometric studies indicated that the third stage of tempering occurs at about 500° F. for Type 410 steels. It was shown that times for failure by hydrogen embrittlement vary with tempering temperatures in the same manner as impact strength varies with tempering temperature.

DENNIS J. CARNEY

Metallography of Titanium*

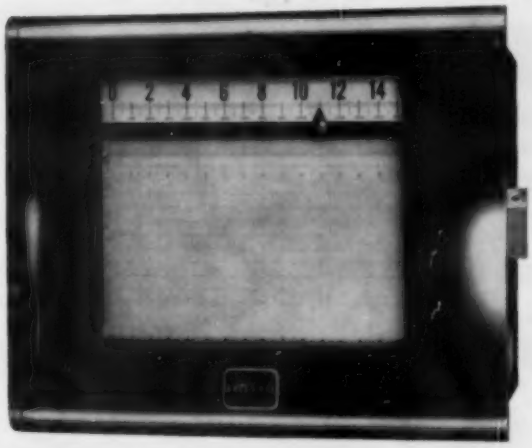
THE martensitic phase alpha-prime in titanium alloys is isomorphous with the lower-temperature modification of titanium (alpha) and may occur during the quenching of alloyed titanium from the higher-temperature phase (beta). This study traces the metallographic history of the martensitic phase on tempering of two beta-stabilized titanium alloy systems – one with 13% Mo and one with 6% Cr.

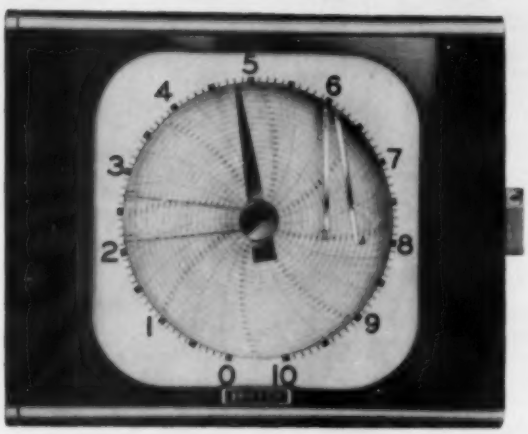
Alloys were prepared by melting titanium sponge (120 Brinell hard) and the alloy ingredient into small pancake ingots in a nonconsumable electrode furnace. Samples were sealed in Vycor bulbs, given pro-

(Continued on p. 194)

*Digest of "Metallography of Tempering of Alpha-Prime in Titanium Alloys", by R. F. Domagala and W. Rostoker, ⓜ 1955 Preprint 25.

WHAT'S NEWS AT BRISTOL . . .





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Get the whole story on these three rugged Bristol Furnace and Oven Controls. Write for free 48-page Bulletin P1260 today. It contains specifications, control diagrams and prices for every type of automatic heating control. The Bristol Company, 106 Bristol Road, Waterbury 20, Conn.

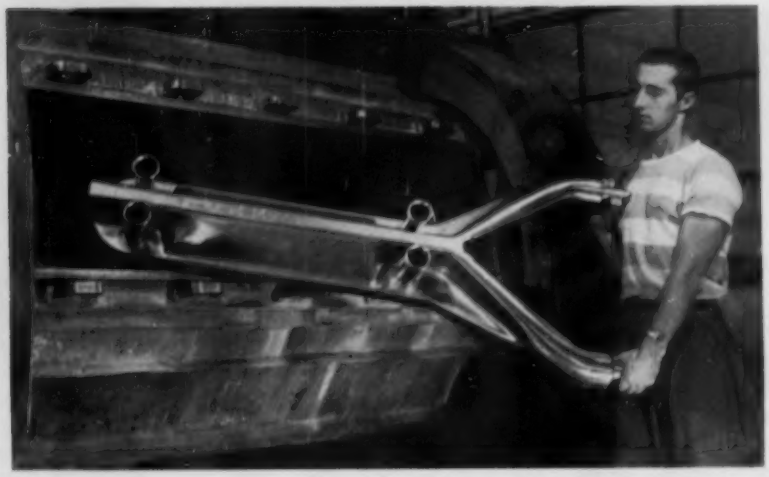
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A large eastern corporation was exploring the possibilities of barrel-finishing stainless steel frames and heat exchanger units.

These frames, measuring 56" x 25", required specially designed fixtures to hold them in the barrel. The first try, according to the manufacturer, was a dismal failure. Numerous types of compounds and chips in varying combinations were experimented with, but none proved satisfactory and costs seemed prohibitive.

Finally, the only way they could do an acceptable job was to scrub the parts by hand with a brush and a soap detergent after tumbling. *And then they learned about LORCO COMPOUNDS!*

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Metallography of Ti . . .

longed annealing treatments at 1830° F. and water quenched. The samples were tempered for varying times at temperatures ranging from 930 to 1380° F.

In the 13% Mo alloy, the authors found the quenched alpha-prime needles to be of simple construction and configuration, each needle appearing to be a homogeneous orientation. Intersection of needles was quite common. Occasional needles formed parallel to each other, entrapping a layer of retained beta between them. At 1290° F. tempering of the 13% Mo alloy occurred slowly by one of two processes: (*a*) a fine precipitation of alpha within the alpha-prime needle resulting in an alpha dispersion in a beta matrix with the ultimate disappearance of the needle, and (*b*) a simple mass transfer across the alpha-prime:beta interface until the alpha-prime was diluted to equilibrium alpha. Surface tension effects presumably broke up the long bands of alpha into small fragments with prolonged annealing times.

In the 6% Cr alloy, the alpha-prime needles were of the simple type found in the 13% Mo alloy or assumed a more complex configuration of randomly oriented alpha-prime platelets interleaving the beta matrix in a broad band. Tempering this material resulted in structures which were essentially the same as the original but more clearly resolved; this occurred by a mass-transfer mechanism across the alpha-prime:-beta interfaces. In some cases, the tempered structure of this alloy consisted of two parallel bands of alpha surrounding a mid-rib of retained beta phase. The authors imply that this structure resulted from an oriented growth of beta within the alpha-prime needle.

An unresolved dark etching effect was noted on some needles of the 6% Cr alloy associated with the 1110° F. tempering treatment, but its nature was indeterminate. It was not possible to establish the identity of $TiCr_2$ as a temper product.

The authors conclude that raising and lowering the tempering temperature appeared to influence only the kinetics of the process but not its essential nature.

R. L. Folkman



Vilter Mfg. Co. Solves 3 problems with Cities Service Lubricants

PROBLEM 1. Formation of carbon on air compressor valves, necessitating shut-down to clean every three months.

PROBLEM 2. Mixing of oil and water on valve gears and bearings of engine driving Vilter's 600 KWH generator. Constant draining required.

PROBLEM 3. Groaning of corliss steam valves on Vilter's condensing, cross-compound steam engine.

Since 1867, Vilter Manufacturing Company of Milwaukee has enjoyed the reputation of solving difficult engineering problems in refrigeration and air-conditioning. So it was natural that when Vilter had a lubrication problem, it would solve that also. Natural, too, that Cities Service Lubricants would be those chosen to carry out the task.

Says Vilter's Chief Power Plant Engineer, James Murphy: "The valves on our two-stage, high pressure air compressor were coating with carbon so badly that we had to shut down and clean them every three months. Then we switched to Cities Service DC-300 Oil. Now, after nine months, valves are perfectly clean and our carbon problem is gone.

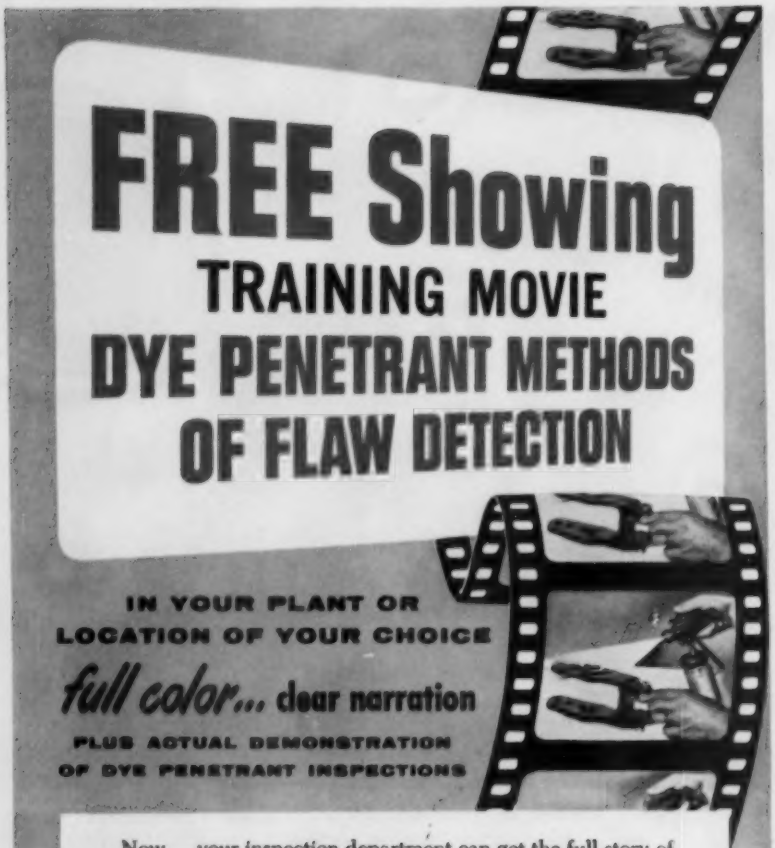
"At the same time we tried Cities Service Pacemaker No. 3 to stop a problem of oil mixing with water on the valve gears and bearings of the steam engine driving our 600 Kilowatt hour generator. The problem ceased and for more than nine months we haven't had to change the oil because it does not emulsify with water.

"We also silenced groaning from the corliss steam valves of this steam engine by switching to Cities Service Optimus No. 3."

If you have a lubrication problem talk to a Cities Service Lubrication Engineer. Chances are he can solve it. Or write: Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.

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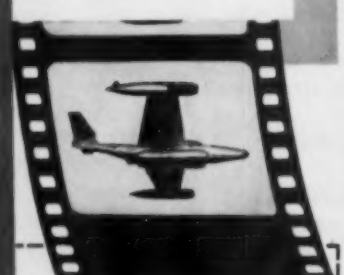
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Static Fatigue of High-Strength Steel*

MOTIVATED by aircraft applications of alloy steels at high strength levels (above 180,000 psi.), a study using stress-rupture tests at room temperature on *notched* tensile bars was made. It provided confirmation that high sustained loads can cause structural damage and fracture at stresses down to 83% of the short-time tensile strength. Before failure, cracking at the root of the notch was detected. For 230,000-psi. S.A.E. 4340 steel this "static fatigue" effect was negligible, but for harder 280,000-psi. steel it was prominent.

Specimens in this study subjected to steady loads for some hours and subsequently broken by conventional tensile testing lost about 25% of their normal strength.

Hydrogen has previously been suspected as the cause of such impaired properties. In this study all wrought S.A.E. 4340 steels melted in vacuum as well as under air or argon, with hydrogen contents from 0.3 to 1.3 ppm., exhibited similar behavior.

Air-melted specimens plated with cadmium under conditions favoring hydrogen absorption fractured at lower stresses than the unplated steel in both short-time and sustained-load tests. Impairment was greatest in the stress-rupture tests, providing a stress versus log-time curve that suggested 130,000 psi. as the static fatigue limit for these conditions and oil quenched and tempered structures at strength of 230,000 psi.

Cadmium plating bars of vacuum-melted 230,000-psi. stock reduced the 20-hr. rupture strength 50%. Baking (350° F. for 1½ hr.), intended to remove hydrogen, affected the susceptibility to static fatigue very little. (Hydrogen was reduced from a range of 0.7 to 1.1 ppm. to a range of 0.6 to 0.7 ppm.) It did restore the tensile strength of both notched and unnotched specimens nearly to that of unplated specimens.

Although hydrogen in steel can adversely affect conventional tensile properties, it evidently is not the key

(Continued on p. 198)

*Digest of "Static Fatigue of High-Strength S.A.E. 4340 Steel", by R. H. Raring and J. A. Rinebolt, © 1955 Preprint 31.



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Static Fatigue . . .

to static fatigue. Cadmium plating is shown to reduce markedly the load-carrying ability of very strong alloy steel. Baking, as required in current specifications, is ineffective for combating the adverse effect. This cautions against depending only on short-time tests for judging the merit of baking.

Awareness of the static fatigue problem is quite recent; the oldest reference cited is dated 1948. It is obviously an area that needs more work if the high strength levels to which steel can be heat treated are to be safely exploited.

Tempering data and resulting hardnesses were missing; these would be welcome to many readers.

The effect of time, the evidence of structural damage short of failure, and the cracking all suggest that a common denominator relating static fatigue, cyclic stress fatigue, and stress-rupture failure at elevated temperatures should be considered in future research.

H. S. AVERY

Deformation Rate Sensitivity of Stainless*

STAINLESS steels lose ductility when subjected to high strain rates at room temperature but the factors causing this strain rate sensitivity have not been satisfactorily rationalized. An explanation has been advanced that since austenitic stainless steels transform when cold worked, the amount of transformation being dependent upon the amount of cold work and upon the rate of cold working, it might be expected that the rate of strain would affect the tensile properties. However, when attempts are made to compare the loss in ductility with the gamma-to-alpha transformation a paradox becomes apparent.

Certain investigators state that the gamma-to-alpha transformation lowers the ductility. If the alpha phase formed during a tensile test

(Continued on p. 200)

*Digest of "The Influence of Strain Rate and Temperature on the Ductility of Austenitic Stainless Steel", by G. W. Form and W. M. Baldwin, ASTM 1955 Preprint 4.



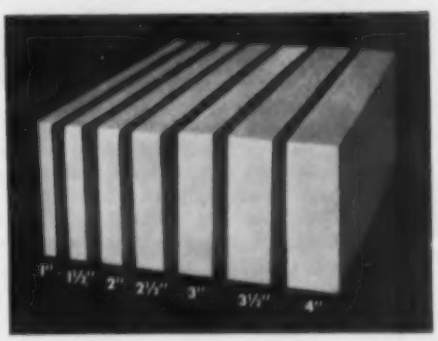
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Deformation Rate . . .

lowers the ductility it would be natural to assume that at low strain rates where ductility is high, less alpha phase is present than at high strain rates where ductility is low. This, however, contradicts other findings which show that the amount of alpha phase drops markedly when the testing speed is increased. Further confusing the issue is the fact that ductility drops at low temperatures where increased gamma phase is known to exist. Thus this investigation was undertaken to study this discrepancy through tensile tests conducted over a wide range of temperatures and strain rates.

Two steels, Types 303 and 310, were selected and tensile specimens machined from fully annealed rods. The low strain rate tests were conducted on standard tensile testing equipment, the intermediate rates on a hydraulic draw bench and the high rates on a drop hammer. Extra precaution was taken for the high and low-temperature portions of this investigation to insure that the specimen temperatures remained constant. Test temperatures were −321, −200, −50, +70, +200, +300, +500 and +750° F.

Strain rate sensitivity was most pronounced at room temperature but was relatively small at low temperatures and disappeared at 500° F. At low strain rates the ductility increases markedly with temperature, reaches a maximum at room temperature and decreases at higher test temperatures. At high strain rates the ductility increases slowly but irregularly as the test temperature increases.

The ductility behavior of the steels investigated must be explained on some other basis than the gamma-to-alpha transformation since both steels exhibit similar properties yet Type 310 showed no gamma-to-alpha transformation at any temperature or strain rate.

In addition, Type 303 did not transform above room temperature where ductility dropped with increasing strain rate.

Where gamma-to-alpha transformation was found in Type 303 (room temperature and below) it was present in amounts that bore no direct relationship to ductility.

H. J. ELMENDORF

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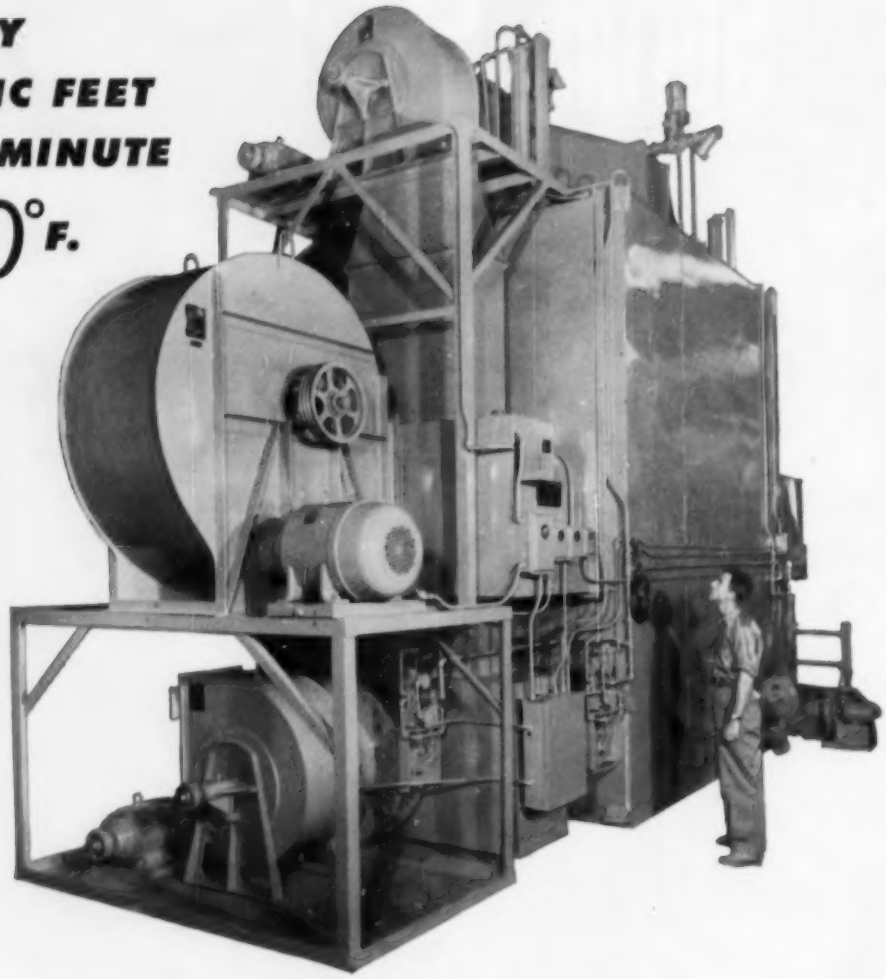
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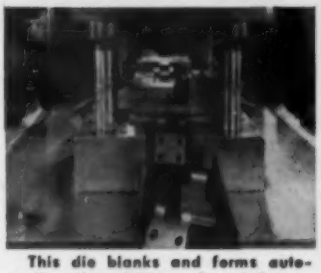
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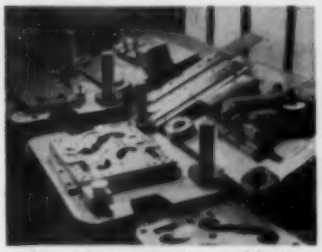
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Shock Loading of Mild Steel*

SUDDEN stresses applied to mild steel may result in elastic behavior, prompt plastic flow, delayed plastic flow, or cleavage fracture. Krafft has examined, with perhaps greater precision, one area of the more extensive previous work on impact and shock loading by Clark and Wood. The data are confined to uniform compressive stresses lasting about 100 microsec. (0.0001 sec.).

The apparatus used a series of axially aligned but longitudinally unrestrained loading bars in the series sequence of (*a*) a loading rod (gun projectile), (*b*) input loading anvil with strain gages, (*c*) the specimen, (*d*) supporting anvil bar with strain gages, and (*e*) a throw-off bar. The energy of the shock wave not used by flow in the specimen is trapped in the throw-off bar, whose velocity is used for calibration. A specimen of 0.20% C killed ship-plate steel, 0.5 in. diameter by 0.5 in., was loaded by projectile impact and the delay between initial stressing and the beginning of plastic flow measured with 2-microsec. accuracy at five temperatures by strain gages and an oscillograph.

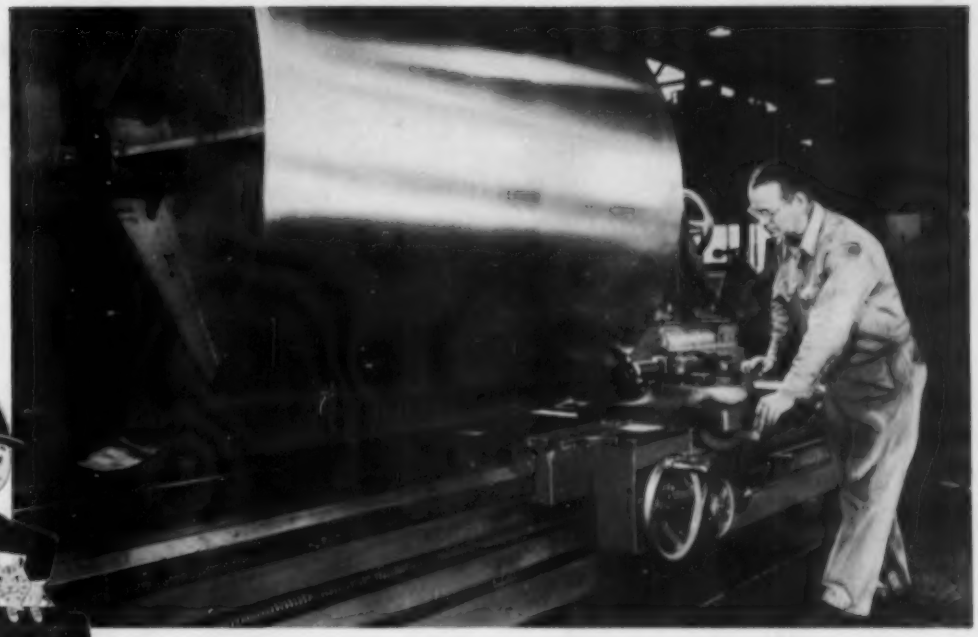
Either no yielding, or plastic flow with no delay, separated by a critical stress of 146,000 psi., was found at −319° F. At −103° F. there was no yielding below 119,000 psi. Above this stress, and in the range from 64,000 to 135,000 psi. at the three higher temperatures, a time delay before yielding was the rule. Delay periods at −103° F. were all below 25 microsec.; at higher temperatures they ranged up to the limit of the apparatus.

The static compressive yield points of the steel tested were 36,000± 1500 psi. and 33,000±500 psi. At the comparable temperature of 77° F. the loading stress for 100 microsec. delay was 80,000 psi. and the flow stress after yielding was 75,000 to 80,000 psi. for delays of 10 to 100 microsec. These values imply greater strength under shock loading than do conventional yield points and suggest interesting possibilities

(Continued on p. 206)

*Digest of "Effect of Temperature on Delayed Yielding of Mild Steel for Short Loading Duration", by J. M. Krafft, © 1955 Preprint 29.

Photo, courtesy Commercial Machining Company, Conway, Pa. Turning 60" dia. stainless steel looping line roll.





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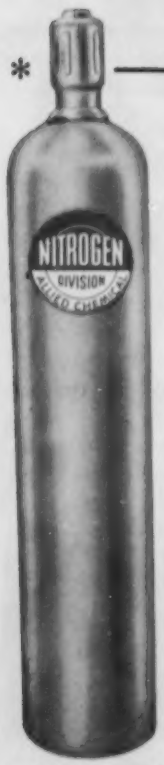
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Shock Loading . . .

if they can be exploited in practice.

The semilogarithmic plots of loading stress versus log delay time seem to follow straight lines. The slopes are steeper than comparable data of Clark and Wood. With decreasing temperatures, stress increases for the same time delay while delay times increase at a given stress level. From his data the author calculates the activation energy of the yielding process as 3000 to 4400 cal. per mole, increasing with decreasing stress levels. He provides plots of log delay time versus reciprocal of absolute temperature at stress levels from 80,000 to 130,000 psi. and of activation energy versus the ratio of yield stress at temperature to that at absolute zero (200,000 psi.).

The critical stress observed at −103° F., together with Neumann lamellae, and their absence at −13° F., 77° F., and 212° F. suggest that time-delay curves can define the critical stress, time and temperature combination for failure by slip.

H. S. Avery

Corrosion Resistance of High-Alloy Stainless*

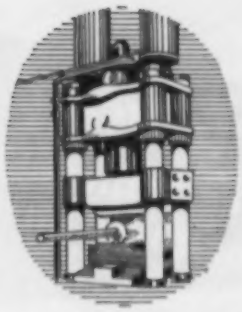
This paper covers a much-needed phase of corrosion resistance of the high-alloy stainless steels, although many investigations have been conducted on the 18-8 Cr-Ni variety. This paper deals with Type 309 (23% Cr, 12.5% Ni) and 310 (25% Cr, 20.5% Ni) and the effect of nitrogen and carbon on corrosion resistance.

Induction melts were made of seven heats of Type 309 and two of Type 310. Two types of solution heat treatment were used—one at a high temperature to insure complete solution of the carbides, and the other at a lower temperature to dissolve approximately 50% of the as-forged or as-rolled carbides. The two carbon levels (0.06% and 0.16%) used in the authors' study required

(Continued on p. 208)

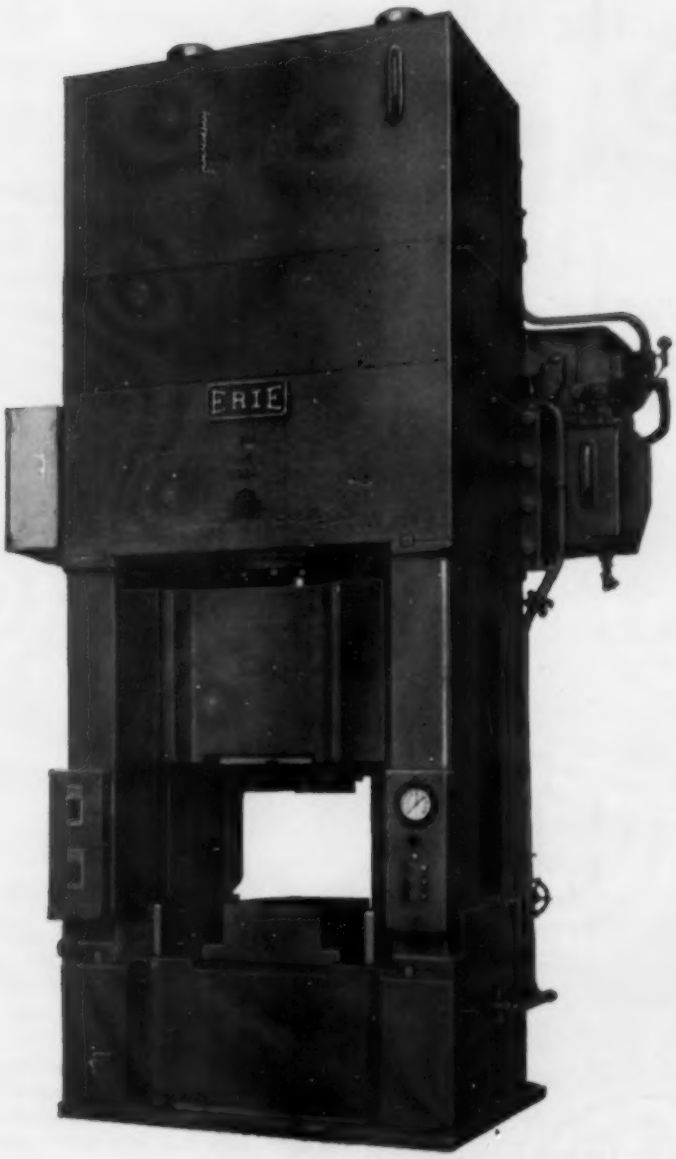
*Digest of "Effects of Chemical Composition and Heat Treatment Upon the Microstructure and Corrosion Resistance of A.I.S.I. Type 309 and 310", by D. J. Carney and E. R. Rosenow, © 1955 Preprint 8.

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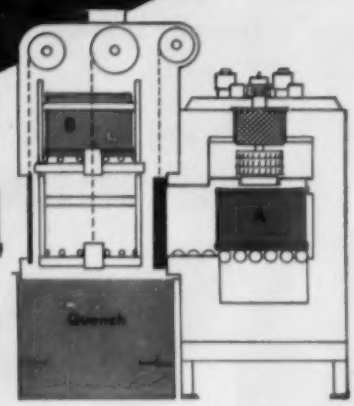
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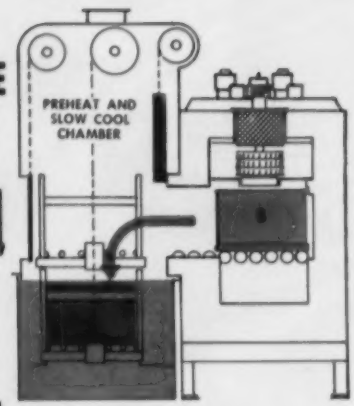
Step 1—LOADING CYCLE

Box A containing full furnace load of parts processing in work chamber. Box B—fully loaded, pre-heats in the upper vestibule. Box C—fully-loaded, waits on conveyor.



Step 2—QUENCHING CYCLE

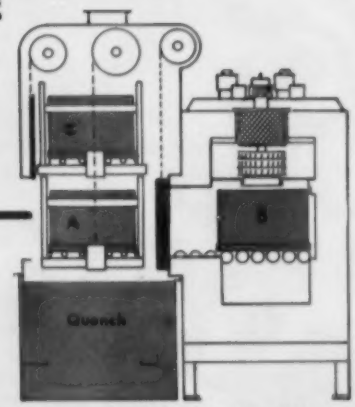
Box A completely processed, moves out to elevator and is lowered into quench; bringing preheated Box B to loading level. Box B is pushed into heat chamber and door is closed.



Step 3—RELOADING CYCLE

After proper interval, outer door is opened. Box C is placed on upper elevator and raised to pre-heat position as Box A is lifted from quench and removed from lower elevator.

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Corrosion Resistance . . .

different temperatures to produce a comparable degree of carbide solution; this was accomplished by heat treating pilot specimens. Cooling rates subsequent to solution treatment were also varied by (*a*) water quenching, (*b*) cooling at 1300° F. per hr. and (*c*) cooling at 300° F. per hr. These cooling rates were used to approximate the cooling conditions which might exist in welded structures. Samples from each heat treatment were tested in 65% boiling nitric acid. Duplicate samples were also run in boiling copper sulphate-sulphuric acid solutions.

Investigation of the Type 310 stainless showed that in both the high-carbon and low-carbon grades the presence of undissolved carbides from the anneal yielded excellent corrosion resistance regardless of the cooling rates. On the other hand, when the annealing treatment dissolved all the visible carbides, satisfactory corrosion resistance was obtained only after water quenching. Slower cooling resulted in failure in both acid treatments. Microscopic examination of the Type 310 showed that in all the failed specimens the austenitic grains were completely encircled by carbides or by carbonitrides. Samples which showed excellent corrosion resistance possessed very few or no carbides in the grain boundary but these were more randomly distributed. The authors were careful not to overlook the effect of grain size, and point out that when all carbide was in solution grain coarsening resulted, whereas those structures showing undissolved carbides were fine-grained. They were unable to isolate any effect of grain size on corrosion resistance.

Both high and low-carbon Type 309 steels were melted with nitrogen content ranging from 0.04 to 0.20%. One heat was purposely made with high chromium and low nickel to study the effect of delta ferrite. Heat treatment and corrosion tests were carried out in the same manner as for Type 310. For heat treatments involving water quenching Type 309 withstood both corrosion tests regardless of carbon content. For both high and low carbon at the lowest nitrogen levels, corrosion resistance for the slower cooling

(Continued on p. 210)



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Corrosion Resistance . . .

rates from solution temperature was improved when using lower solution temperatures. In this respect Type 309 steel was comparable to Type 310. However, these slower cooling rates did not allow Type 309 to meet the accepted limits for the boiling 65% nitric acid test.

Increasing nitrogen content at the low carbon levels showed a significant improvement in corrosion resistance of Type 309. For the heat melted to study delta ferrite (approximately 20%) corrosion resistance was satisfactory in boiling nitric acid at all solution temperatures and cooling rates investigated.

The authors point out that carbide distribution is a very important factor in corrosion resistance of Type 309 and 310 steels. Random distribution of the carbides gives the best resistance. When the microstructure prior to solution annealing contains intergranular carbides or when they are completely dissolved during solution treatment, the steel is susceptible to intergranular corrosion.

R. D. CHAPMAN

Creep Resistant Zirconium Alloys*

THE SIMILARITY of zirconium to titanium has impelled recent attempts to obtain zirconium-base alloys with high strength. From more than 25 published binary systems Chubb has selected the most promising alloys for survey and modification. Using hot forged and rolled stock he studied tensile properties at 77, 435 and 930° F. Hot hardness in vacuum was determined at temperatures up to 1500° F. for some alloys and creep was measured at 930° F.

The alpha-to-beta transformation temperature, 1585° F., was considered the upper useful limit (hardness of zirconium drops sharply to below Vickers 2) and addition elements were classified by their tendency to raise or lower this temperature (peritectoid or eutectoid type,

(Continued on p. 212)

*Digest of "Progress in the Development of Creep-Resistant Zirconium Alloys", by W. Chubb, ⓐ 1955 Preprint 27.

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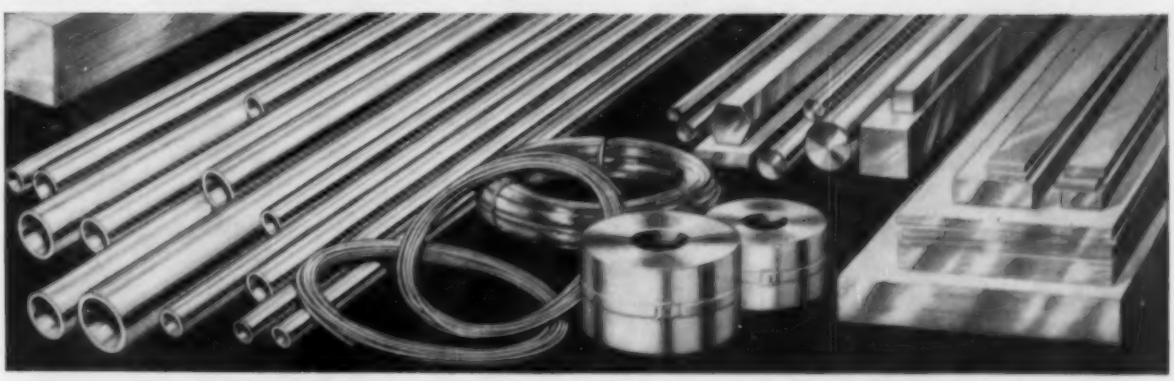


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Zirconium Alloys . . .

respectively). The former, notably aluminum and tin, are effective hardeners but produce brittleness. The latter also increase hot workability. Ternary alloys of a "peritectoid-eutectoid hybrid" effectively combine both.

The yield strength and tensile strength of zirconium at room temperature are 15,000 and 35,000 psi., respectively. Additions of 2% molybdenum, columbium, tantalum, aluminum, chromium and tin raise the yield strength to values varying from 27,000 to 63,000 psi., and tensile strength to 45,000 to 74,000 psi. Additions of 4% raise the values to 49,000 to 90,000 psi. and 73,000 to 103,000 psi., respectively. Molybdenum and columbium have the greatest strengthening effect.

At 435° F. Mo, Cb, Al and Sn strengthened in that order of effectiveness but their comparative effects were smaller. At 930° F. the four were nearly equivalent. Hot hardness values suggested that above 930° F. aluminum and tin were most effective.

Ductility decreases as strength increases, especially at room temperature. The elongation of alloys containing 2% Mo drops from 30 to 55% to less than 10%. Alloys with hardness above Vickers 30 at the hot rolling temperature are difficult to work without cracking.

A change in slope of the hot hardness curves occurs near 900 to 1100° F. Above this range the best creep resistant alloys will probably be based on the Zr-Al and Zr-Sn systems. Since the high absorption characteristics of Cr, Ta and Ti are undesirable in nuclear devices, ternary alloys using Al, Mo, Cb and Sn were studied most completely.

The brittleness near 1470° F., which limits the usefulness of Zr-Al-Sn alloys, is partially overcome by additions of Mo or Cb. These elements cause the beta phase to appear and its presence produces brittleness, if the alloys are cooled rapidly for maximum ductility. Hot rolling at minimum practical temperatures is necessary. Higher strength can be developed by working or heating above the minimum.

Zirconium containing 2.9% tin and

(Continued on p. 214)

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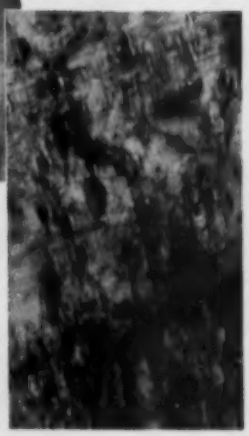
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(Standing) Dr. H. Fernández-Morán, Director of New Institute for Neurology and Brain Research, Caracas, Venezuela, and Dr. Robert G. Picard, Manager of RCA Scientific Instruments Engineering, operating the Electron Microscope.



Ultrathin (200 A.U.) section of aluminum. The fine structure of the metal and electron optical phenomena characteristic of thin crystalline layers (extinction contours) can be seen.



Morán Ultramicrotome with diamond knife for producing ultrathin serial sections of 50—200 A.U. thickness of biological tissue, bone, metals, crystals and other hard materials.

Slices of metals less than four ten-millionths of an inch thick have been studied by Dr. H. Fernández-Morán, working with an RCA Electron Microscope and his newly developed ultramicrotome at the Karolinska Institutet, Stockholm, Sweden. He is now continuing his work at the Institute for Neurology and Brain Research, in Venezuela, which is being equipped with RCA EMU-3 Electron Microscopes.

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Zirconium Alloys . . .

1.5% molybdenum is among the best of the ternary alloys. It is most ductile when annealed at 1345° F. for 3 hr. Such a treatment produces a yield strength of 71,200 psi., ultimate of 90,600 psi., and 20% elongation. The highest strength (143,300 psi.) and lowest ductility (2% elongation) occur after air cooling from 1650° F. Intermediate strengths are obtained by water quenching or by furnace cooling.

Of 19 alloys creep tested at 930° F. the limiting creep stress of hot workable binaries ranges up to 10,500 psi. for 1% total deformation in 1000 hr. The ternaries range from 10,500 to 20,000 psi. (for the 2.9% Sn, 1.5% Mo alloy). Pure zirconium gives 1800 psi. and sponge zirconium (containing oxygen) 2400 psi. The 5.4% Al alloy reaches 22,000 psi. (and Vickers 130) but lacks the required fabricability.

A limiting creep stress of 10,000 psi. at 930° F. can be met by Zr-Al alloys, Zr-Sn-Al alloys and the "peritectoid-eutectoid hybrid" family. Creep resistant zirconium alloys are in their early development stage, and it is suggested that Zr-Al-Mo and Zr-Al-Cb systems will surpass the alloys of this survey and provide the basis of more complex alloys of superior creep strength.

H. S. AVERY

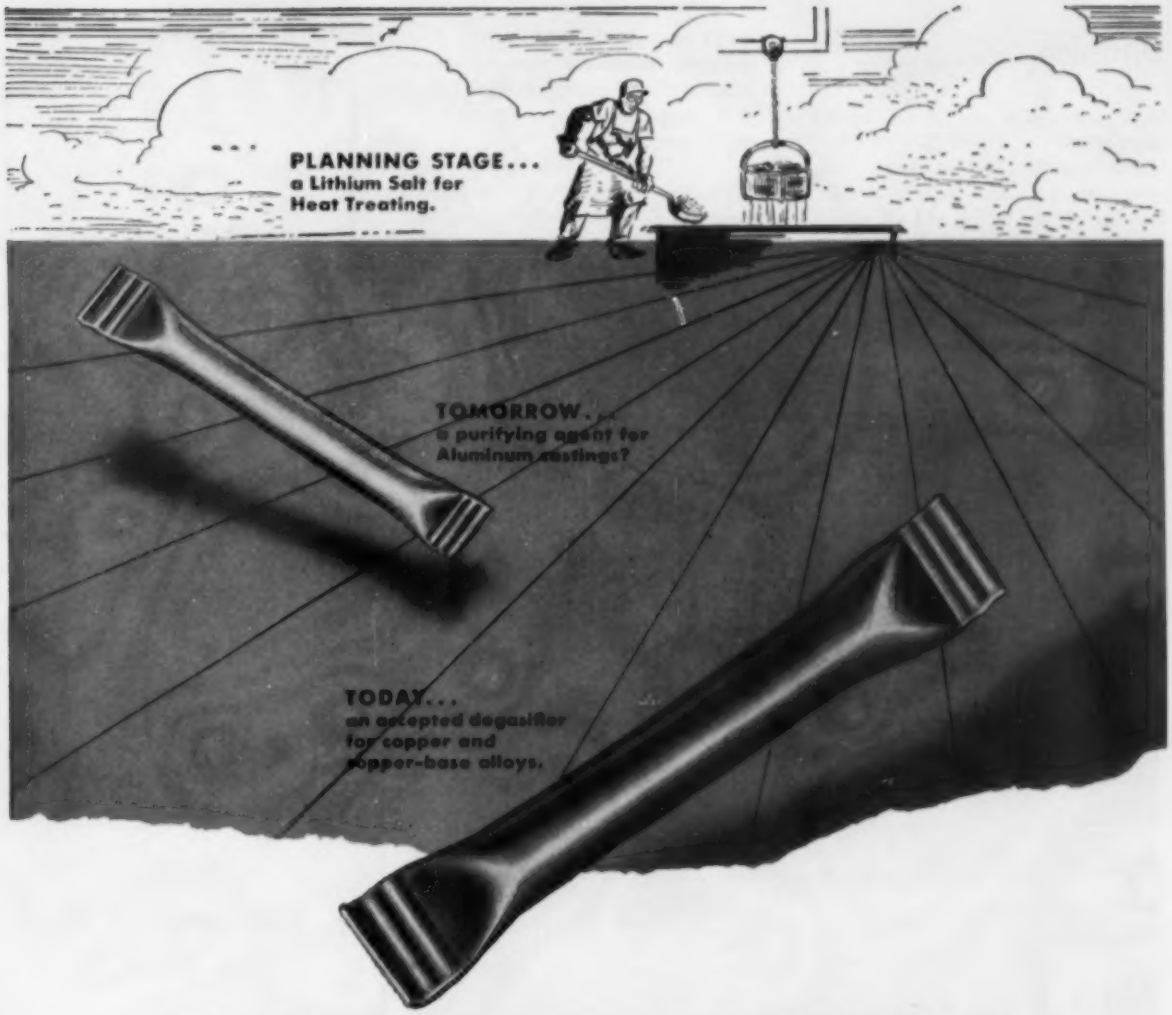
Diffusion of Carbon in Titanium*

THE interstitial elements, carbon, oxygen, hydrogen, and nitrogen, exert a serious effect on the physical and mechanical properties of titanium and its alloys. Therefore, knowledge of the behavior of these elements in titanium plays an important role in such metallurgical processes as heat treatment, homogenization and aging.

Studies of the diffusion rates of carbon in alpha and beta titanium used diffusion couples consisting of

(Continued on p. 216)

*Digest of "The Rate of Diffusion of Carbon in Alpha and Beta Titanium", by F. C. Wagner, E. J. Bucur and M. A. Steinberg, © 1955 Preprint 32.



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Lithium has been long established in the nonferrous foundry industry as a degasifier, deoxidizer, desulfurizer and general purifying agent, particularly for high conductivity copper castings and copper-base alloys. The small amounts required put both the economics and technique within the limits of everyday nonferrous foundry operation. Research now under way suggests that Lithium is equally valuable as a degasifier for aluminum castings. Further extensive research on various Lithium Salts holds vast promise of valuable benefits to be gained for low temperature heat treating baths. Why don't you look into this miracle element? This revolutionary technique is within *your* reach. Write for details.

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Diffusion . . .

high-purity titanium and various titanium-carbon alloys. The couples were butt welded together, the specimens vacuum-annealed to diffuse carbon across the welded interface, and carbon distribution across the diffusion zone determined.

Diffusion rates were determined over the temperature range of 1355 to 2100° F. by the application of Fick's second law of diffusion. The diffusion coefficients at various temperatures are shown in the table.

By employing the Arrhenius-type equation:

$$D = D_o e^{-Q/RT}$$

activation energies (Q) obtained from the D values in the alpha and beta ranges were 43,500 and 48,400 cal. per mol, respectively.

Thus, by substituting the respective D_o and Q values in the above equation, the authors derive equations whereby diffusion coefficients for specific temperatures can be directly calculated. For example:

D (alpha) = $5.06\ e^{-43,500/RT}$
(1290 to 1470° F.)

D (beta) = $108\ e^{-48,400/RT}$
(1690 to 2190° F.)

Within the limits of experimental error, the rate of diffusion of carbon in titanium is independent of concentration.

From the experimental data, the authors derived the solubility limits of carbon in titanium for the alpha and beta temperature range as shown in the table.

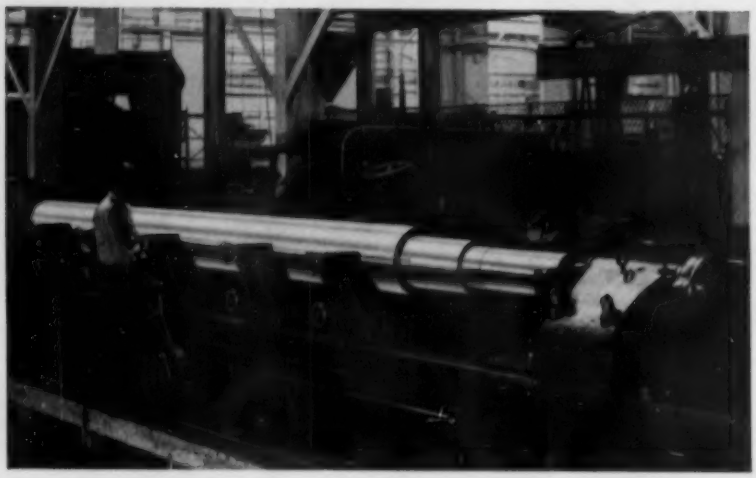
R. L. Folkman

Diffusion of Carbon in Titanium

Temp. °F.	D*	Solubility Limit, % C
	Alpha Titanium	
1355	2.0×10^{-9}	0.240
1440	5.0×10^{-9}	0.258
1535	1.3×10^{-8}	0.316
	Beta Titanium	
1740	2.5×10^{-7}	0.160
1920	1.0×10^{-6}	0.188
2100	4.0×10^{-6}	0.224

*Diffusion coefficient expressed in sq. cm. per sec.

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Decomposition of Ti-V Alloys*

In the titanium-vanadium system, vanadium is completely isomorphous with beta titanium and is soluble to a few per cent in alpha titanium. Iodide-base titanium-vanadium alloys were studied in the condition as quenched from the beta field at 1790° F. Martensite or alpha prime was formed from beta without change of composition, as evidenced by a linear decrease in the *a* and *c* lattice parameters of the hexagonal close-packed lattice up to 8 at.% vanadium. There was a slight deviation from Vegard's law noted in the *a* parameter, but not in the *c* parameter, at about 10 at.% vanadium. A mild hardening effect (up to Vickers 100 max.) accompanied the supersaturation of the equilibrium alpha

(Continued on p. 218)

*Digest of "Nature and Decomposition Kinetics of Alpha Prime in Titanium Alloys", by F. L. Brotzen, E. L. Harmon and A. R. Troiano, © 1955 Preprint 24.

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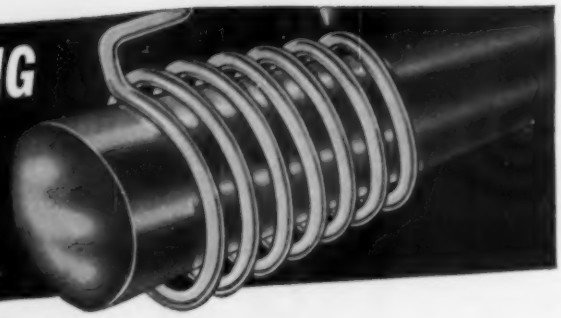
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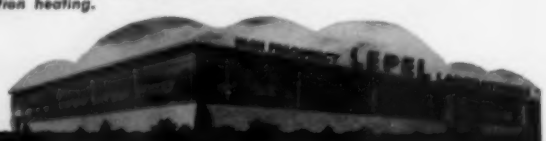
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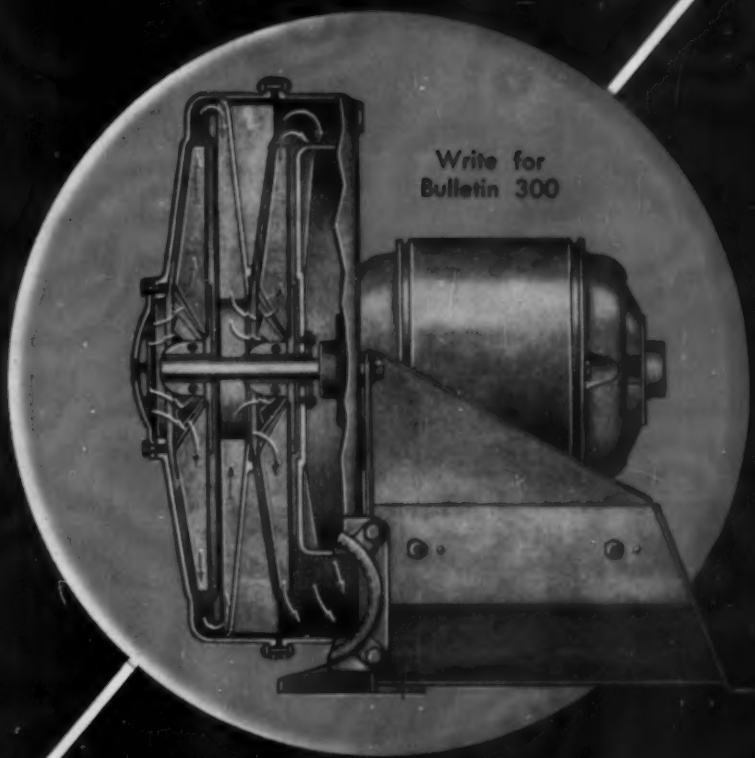
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Ti-V Alloys . . .

lattice by vanadium. Retained beta was first noted by X-ray diffraction at about 12.5% vanadium, together with alpha prime, and was found to be considerably harder than martensite. This high hardness was accompanied by small amounts of the transition omega phase in beta detected by X-ray diffraction. Alpha prime was not found beyond 15% vanadium, but the beta phase remained hard through 17.5% vanadium and then decreased in hardness at 20% vanadium, at which point omega no longer was detected.

The kinetics of the tempering of alpha prime in a 7.5% vanadium alloy were studied in the range 660 to 1020° F., using a resistance method. As tempering proceeded the resistance dropped rapidly at first and then leveled off as equilibrium was approached. It was assumed that the fraction of alpha prime transformed was proportional to the fractional change in resistance. The resistivity data were plotted and an activation energy of 15,000 cal. per mole was obtained for the tempering of alpha prime titanium-vanadium containing 7.5% vanadium.

R. I. JAFFEE

Solidification of Aluminum*

THIS paper demonstrates the effects of vibration during solidification on grain refinement, pipe suppression, columnar grain growth and dendritic growth of an aluminum alloy. Vibration was measured in terms of two independent parameters — frequency and peak-to-peak displacement. Each of these parameters was correlated with ingot structure, particularly grain size.

Induction furnace heats of an aluminum-copper-silicon alloy were cast into two 50-lb. ingots, one vibrated and the other cast without vibration. Vibration was generated by a commercial electromagnetic unit which pulled a steel table con-

(Continued on p. 220)

*Digest of "The Influence of Vibration on the Solidification of an Aluminum Alloy", by R. S. Richard and W. Rostoker, © 1955 Preprint 23.

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Solidification of Al . . .

taining the mold against steel springs by means of alternating current. The motion of the table and mold was sinusoidal such that the frequency and peak-to-peak displacement could be varied and measured.

Grain size was determined from a lineal count of a photomacrograph of a vertical slice from the center of each ingot. Porosity was determined by density and by volume calculation of voids from weight measurements before and after impregnation with glycerine.

Peak-to-peak displacement, peak velocity, peak acceleration and power input all correlated with grain size. Increases in each resulted in grain refinement. However, grain size versus displacement yielded a simple and frequency-independent correlation. Since the other factors are only derivatives, displacement was regarded as the fundamental property. This means that higher frequencies are not necessary for grain refinement by vibration.

A direct comparison of vibration under conditions of rigid coupling (mold fixed to table), and under impacting (mold resting on table) showed that rigidly coupled vibration produced the greatest degree of refinement. Vibration was found to minimize the grain coarsening tendency as a result of high pouring temperatures and slow cooling rates.

A series of experiments with varying degrees of vibration intensity showed positive evidence that pipe and other macroshrinkage defects could be minimized by vibrating, with lower frequencies being most advantageous. Chemical analysis of ingots indicated that vibrated ingots exhibited more inverse segregation than unvibrated ingots.

The authors offered the hypothesis that vibration increases the rate of nucleation by a pressure effect. They oppose the theory that grain refinement results from fragmentation of primary crystallites. Their data and other similar data tend to support this hypothesis.

To be effective it was found necessary to vibrate during the solidification period. Vibration did not appear to condition the liquid.

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Zirconium-Chromium Alloys*

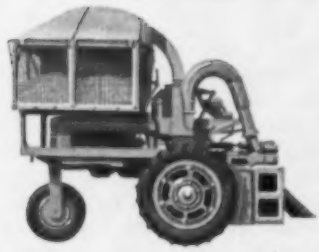
CHROMIUM is of interest as an alloying element with zirconium for atomic energy applications because of its moderate neutron absorption and ability to impart elevated-temperature strength and oxidation resistance to many metals. The zirconium-chromium system is a eutectoid system with essentially no solid solubility in the alpha phase; strengthening by particle hardening without solution hardening can be studied in alpha-annealed material.

Using pure zirconium and electrolytic chromium, heats of 0, 1, 3, 10, and 18 at. % nominal chromium content were melted in a tungsten-arc furnace with a water-cooled copper crucible and argon atmosphere. Alloys of 10 and 18% chromium were hot rolled to 90% reduction using iron or stainless steel sheaths; lower-chromium alloys were alternately cold rolled and annealed in vacuum.

Tensile tests were conducted in liquid nitrogen at –320° F., in air from 75 to 700° F., and in vacuum at 930° F. In general, strength in-

(Continued on p. 222)

*Digest of "Tensile Properties of Zirconium-Chromium Alloys — Particle-Strengthening Effects", by J. H. Keller, © 1955 Preprint 26.













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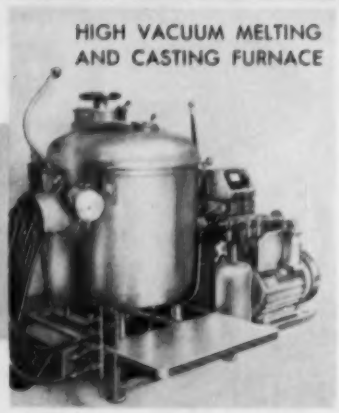
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Zr-Cr Alloys . . .

creased and ductility decreased at all temperatures with increase in chromium content.

The density of the second-phase ($ZrCr_2$) particles was calculated from its known crystal structure. Curves of true stress for true plastic strains of 0.002 and 0.05 were plotted against volume fraction $ZrCr_2$ and gave a straight line that intersected the zero volume fraction at the stress value obtained for pure zirconium. It is suggested that the strengthening effect of the system is independent of the particular sizes, shapes, and number of particles, and approaches a simple law of mixtures. Although the numerical increase in strength from the second phase apparently is greater at lower temperatures, the per cent increase is essentially the same at all temperatures.

The conclusions are as follows:

1. The tensile properties of zirconium-chromium binary alloys containing up to 18% Cr are given for the range of –320 to 930° F.

2. Stress-strain data indicate no solid solubility of $ZrCr_2$ in alpha zirconium.

3. A linear relation observed between flow stress and volume fraction of compound suggests that the strengthening effect in this system follows the law of mixtures.

4. The particle hardening effect was found to increase with increasing strain in the range 0.002 to 0.05 true strain.

G. A. FRITZLEN

Effect of Silicon in High-Strength Steel*

STUDIES were made on two commercial types of high-strength steels, A.I.S.I. 4340 and A.I.S.I. 4325, with two levels of silicon content. Recently, steels with relatively high silicon content have been used for very high-strength structural requirements, and, of course, silicon steels have been employed for many years in springs.

Mechanical property determina-

(Continued on p. 224)

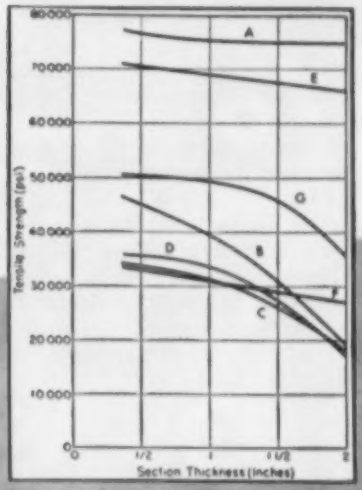
*Digest of "Some Effects of Silicon on the Mechanical Properties of High-Strength Steels", by C. H. Shih, B. L. Averbach and Morris Cohen, 1955 Preprint 9.



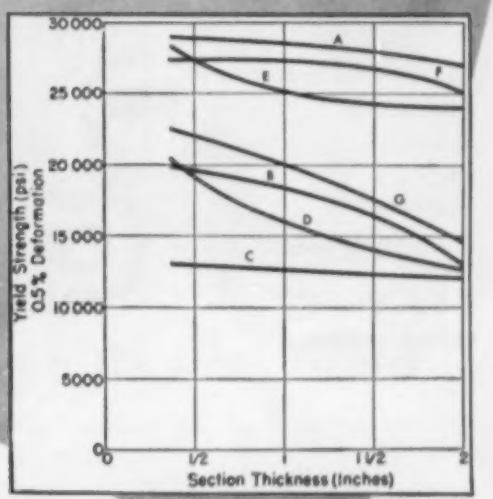
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with AMPCO* Metal



Tensile strengths of various non-ferrous metals vs. section thickness



Yield strengths of various non-ferrous metals vs. section thickness

Examine these charts carefully — they tell a story that can save you money and put extra life and dependability into your product.

Look, for instance, how other non-ferrous metals show a sharp decrease in mechanical values as casting cross-sections increase. Ampco remains practically constant — you require less metal.

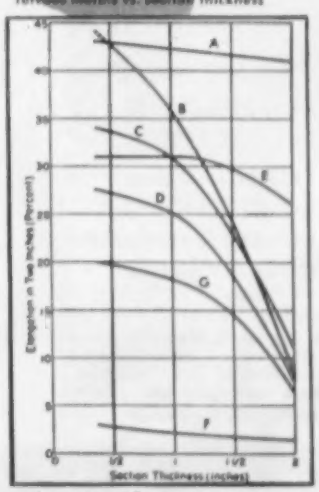
Note Ampco's unusually high tensile and yield strengths compared with conventional bronzes — you use lighter sections to do a better job. And Ampco Metal weighs 10 to 15 percent less than other bronzes — so you can make important weight reductions.

Fact is, Ampco Metal's high strength-to-weight ratios can mean real savings for you — savings in material and money. Consult your nearby Ampco field engineer for full information or write us.

CHART REFERENCE

- A. Ampco Metal
- B. Tin Bronze (88-8-4)
- C. Red Brass
- D. Tin Bronze (85-5-5-5)
- E. Manganese Bronze
- F. Aluminum Alloy
- G. Silicon Bronze

Charts courtesy Materials & Methods and Westinghouse Electric Corp



Elongations (2") of various non-ferrous metals vs. section thickness

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D-43

Effect of Silicon . . .

tions were conducted on specimens prepared from high and low-silicon heats of each grade. The effects of increasing silicon to 1.5% were observed on the mechanical properties and hardenability of both steels. Investigation on the tempering kinetics, including microstructural changes, now underway, appears to indicate that silicon retards almost all of the tempering phenomena.

Data were derived from tensile specimens prepared from forged rounds which were annealed, normalized, austenitized, oil quenched and tempered. The method developed by Muir, Averbach, and Cohen (A.S.M. *Transactions*, Vol. 47, 1955, p. 380) was used to determine elastic limits, while conventional means and apparatus were used to obtain numerous other tensile data. It was observed that 4340 steel has about the same maximum elastic limit as carbon steels; however, the elastic limit does not drop as rapidly at higher tempering temperatures.

Higher strengths may be obtained in the silicon steels without a corresponding loss in ductility or in Charpy impact strength, if tempering in the embrittlement range is avoided. The addition of silicon increased the maximum strength at each carbon level of the respective grades, 4340 and 4325. Ultimate tensile strength levels of 280,000 to 300,000 psi. are obtainable in 4340 (1.5% Si) steel, with 6.5 to 8% elongation and about 14 ft-lb. in V-notch impact toughness at room temperature. The 4325 (1.5% Si) steel, however, has significantly higher notch toughness than the 4340 steels. At low strength levels, less favorable impact properties are encountered with both grades of silicon steel. As the tempering temperature is increased above approximately 700° F., the impact properties of regular 4340 and 4325 are superior to those of the high-silicon steels.

Studies correlating rotating-beam endurance limits to elastic limits obtained from the repeated load method strongly indicated that a relation exists between endurance limits and elastic limits. It was further observed that the maximum useful hardness with regard to elastic and endurance limits for the 0.40% carbon steels appears to lie in the range of Rockwell C-45 to 51, but that higher hardness might give microyielding and poor fatigue life.

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Fatigue Tests on British Wrought Steel—Part II*

IN 1944 the Bristol Aeroplane Co., Ltd. started another investigation of the fatigue of various types of steel to supplement the earlier work of the Inclusions Subcommittee (see digest of the first section of this paper in *Metal Progress* for September, p. 166). For this work ½ to 1-in. diameter bars, or 7⅛-in. O.D. tubes of ⅜-in. wall thickness, of chromium steels were used. They represented five different kinds of electric melt-

(Continued on p. 226)

*Digest of "Fatigue Tests on Rolled Alloy Steels Made in Electric and Open-Hearth Furnaces", by P. H. Frith, *Journal of the Iron and Steel Institute*, Vol. 179, May 1955, p. 26-33.



The Most Valuable Information for the Heat Treater...

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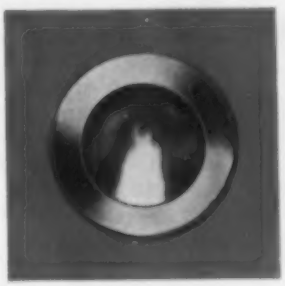
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Fatigue Tests . . .

ing practice, as well as two kinds of British and one of Swedish openhearth steels, all intended to be especially clean. The specimens were heat treated to a hardness of about Vickers 750, and longitudinal reversed-bending fatigue tests were made. Tests for retained austenite were made magnetically and by X-ray diffraction, and in some specimens the types of inclusions present were determined by metallographic or microradiographic methods.

The fatigue limit of the basic electric arc steel heat treated to between Vickers 740 and 820 was about 85,000 psi.; that of the British induction-melted steel was 87,000 to 101,000; that of the Swedish acid openhearth steel was 82,000 to 105,000; and one British neutral openhearth steel showed a fatigue limit of 114,000 psi.

Variations in fatigue resistance between the steels were further explored by making one reversed-bending test on each heat at 112,000 psi. stress. If this specimen did not break at 20 million cycles, another specimen of the same heat was tested for an equal number of cycles at 123,000 psi. stress. If the first specimen broke, however, the second test was run at 101,000 psi. stress.

The basic arc furnace steel made by normal practice showed inferior fatigue resistance, only one heat out of 16 enduring 20 million cycles at 112,000 psi. Modifications in melting practice, which are unfortunately not reported, improved this record to 3 unbroken out of 13. By using "a siliceous slag instead of a normal lime silicate slag" (no explanation is given as to how this was done in a basic furnace, which apparently must be assumed since acid electric practice is classified separately), the results improved to 12 unbroken out of 14 tests, after 20 million cycles at 112,000 psi.

Only one heat each of acid arc furnace and induction melted steel was tested, the latter showing a failure at 101,000 psi., and the former no failure at 112,000 psi. The acid openhearth steels showed 6 unbroken out of 8 tests at 112,000 psi. (or three heats out of five tested), and the neutral openhearth steels 17 unbroken out of 27 tests (26 heats).

(Continued on p. 228)

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The part shown is just one of over 25 parts, large and small, which alert J & H engineers have converted from old-fashioned brazing methods to modern, automatic TOCCO. Overall brazing costs (TOCCO brazing versus former methods used) are down 75%—brazing speed, up 100%.

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Fatigue Tests . . .

An acceptance test is suggested, requiring that a specimen heat treated to Vickers 750 should remain unbroken after 5 million cycles with a reversed bending stress of 123,000 psi.

Three of the basic electric steels made by normal practice were examined metallographically and found to contain spherical silicate or TiCN inclusions considered detrimental to the fatigue properties. This was confirmed by fairly complete microradiographic tests. The fatigue resistance was comparatively low whether few or many of the spherical inclusions, not deformed in rolling, were present. A heat of basic electric steel made by modified practice, in which none of these inclusions were found, and two heats in which the inclusions were duplex and partly deformed in rolling, had much better fatigue resistance. Of the 12 heats made in a basic arc furnace with a siliceous slag, only one had poor fatigue resistance, and the spherical undeformed inclusions were found in it, but not in three of the other heats examined. Some steel from one basic arc furnace heat that contained these inclusions and had inferior fatigue resistance was remelted in a vacuum induction furnace; the remelt was free from the objectionable inclusions, and had much better resistance to fatigue.

The spherical, undeformed inclusions were not found in nine heats made by acid or neutral processes, but four of them had rather low fatigue resistance.

No correlation was found between the fatigue resistance of these chromium steels and the results of magnetic or X-ray diffraction tests for retained austenite at the tested parts of the fatigue specimens. Austenite retained in hardening would not be expected to impair the fatigue resistance, because for hardening most of the austenite must break down to martensite with expansion, thus leaving any retained austenite under compression. This is not true of austenite formed in grinding, however, when local contraction must occur at the surface. Some repeated impact tests on studs showed that heavy grinding could reduce the fatigue limit 40%, and the original fatigue resistance could be restored by shot-blasting.

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Problems of the Thermal Barrier*

At speeds more than twice as great as that of sound, so much heat is developed by friction between aircraft and the atmosphere that materials of construction are seriously affected. The problem of heating is not serious above the denser layers of the atmosphere where pilotless aircraft would attain their highest speeds, but when the denser atmosphere is re-entered toward the end of a flight the amount of heat developed could be sufficient to melt many metals. Possible methods of preventing total failure from this cause are: decreasing the speed by reverse thrust, surface insulation, transpiration cooling, or absorption of heat by a part of the structure even with some melting. The latter expedient has been tested with models in a supersonic wind tunnel and shows some promise.

Designing piloted aircraft to en-

(Continued on p. 230)

*Digest of "Problems of the Thermal Barrier", by G. Gerard and G. T. Hayes, *Mechanical Engineering*, Vol. 76, December 1954, p. 966-977.

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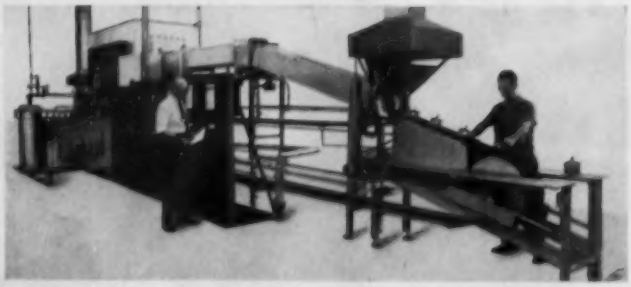
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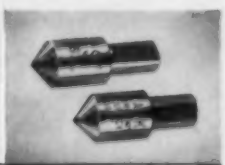
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Thermal Barrier . . .

dure the temperatures produced by aerodynamic heating seems impractical without insulation or a cooling system. A chemically fueled airplane with a wing loading of 330 lb. per sq. ft. flying at 3.5 times the speed of sound at 70,000 ft. altitude, if not insulated, would have to use 25% of its total flying horsepower for operation of a cooling air-fuel heat exchanger, but if insulated with the equivalent of 1 in. of fiberglass the cooling horsepower would be only a few percent of that required for flight. However, practical insulating materials for the high temperatures and forces involved are not yet known.

The compressor for a turbojet engine in a plane flying at 2.8 times the speed of sound would receive air at about 650° F. and discharge it at about 1100° F. (instead of the normal 500° F.). These temperatures introduce difficulties in the design of gas turbines. For operation up to the speed of sound an increase in inlet temperature from 1600 to 1800° F. allows 22% increase in fuel addition per pound of air, but at 2.5 times the speed of sound the same 200° F. increase allows 44% increase in fuel addition per pound of air. Thus, higher turbine temperatures become doubly important.

The fuel system of a plane flying at more than the speed of sound should be insulated to decrease vaporization loss but this would decrease the fuel capacity. Lubricating oils would need to operate at from –65 to 800° F. Air induction and engine cooling for supersonic planes also involve special problems.

For cooling crew compartments and electronic equipment the surrounding air cannot be used as a "heat sink" or cooling medium because of the layer heated by friction. The aircraft structure and fuel are insufficient for use as "heat sinks" at supersonic speeds, and a water-evaporative system seems to be the best expedient.

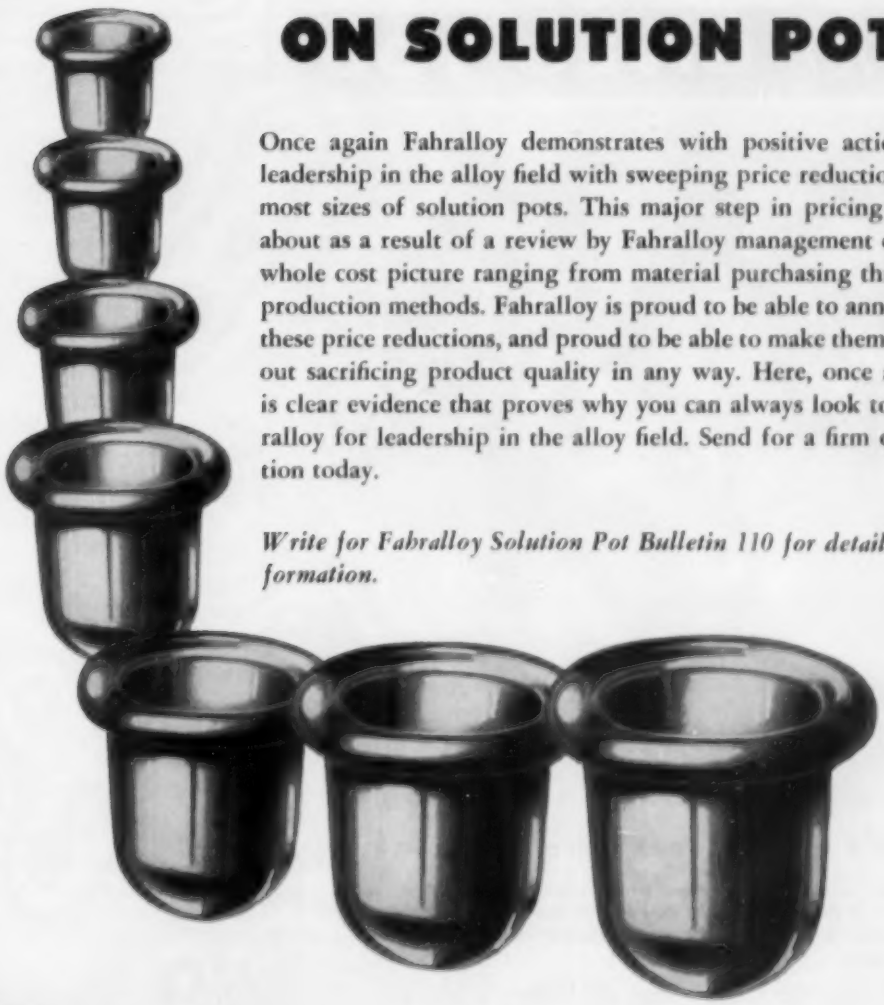
At three times the speed of sound and an altitude of 50,000 ft. the outer skin of an airplane may reach 540° F. in 200 sec., while the supporting beams have a temperature of only 110° F. The resulting difference in thermal expansion in an

(Continued on p. 232)

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Thermal Barrier . . .

average structure may produce a tensile stress of over 70,000 psi. Designing to permit permanent deformation to reduce this stress is a possible solution. Thermal buckling, which would change the surface configuration of the plane, may occur under these high stresses. Since supersonic aircraft are usually expected to operate for only short periods of time, the structures may be designed for creep of as much as several tenths of a percent deformation per hour. Creep helps to distribute stresses more evenly in the structure, and can facilitate weight saving if expected life is short.

To attain minimum weight, supersonic aircraft are designed to have the skin act as the main load-carrying member. In modern design, multicell, or post, construction is preferred over the previously used stringer panel type. For short-time tension loading, a given ultimate strength is attained with the least weight, between 200 and 800° F., by titanium alloy RC-130 A, all aluminum alloys being inferior. (Stainless steel is not compared.) Above 850° F., Inconel "X" weighs less for the same strength. For compressive and shear loading, however, the aluminum alloys 2024-T (24 S-T), 7075-T (75 S-T) and 7178-T 78 S-T) are all superior in weight-strength ratio to RC-130 A up to about 600° F. The titanium alloy is best from about 700 to 1000° F. To overcome all the problems that arise from the high temperatures generated, about twice as much structural weight is required for an airplane operating at 2.5 times the speed of sound as for one at normal room temperatures. The weight penalty for higher speeds increases at an even greater rate. Sustained flight seems limited at present to about 3.5 times the speed of sound by weight requirements, though very brief flights at higher speed may be possible.

Another calculation from high-temperature test data shows that for the same strength at 400° F. as at 75° F., aluminum alloys must be increased in weight 65% for short-time loading and about 250% for 100-hr. loading, while titanium alloys must be increased 23% in weight for short-time and about 38% for 100-hr. loading. (Again stainless steel is not compared.) Since some alloys have greater resistance to creep in the cast condition than when wrought, it is suggested that the use of more castings in aircraft might lead to economies. Another suggestion is that refractory oxides, which resist corrosion and are strong at high temperatures, might be used for conditions too severe for metals. Adding more material does not reduce thermal stresses, but the use of Invar, with low thermal expansion up to 800° F., is considered very promising.

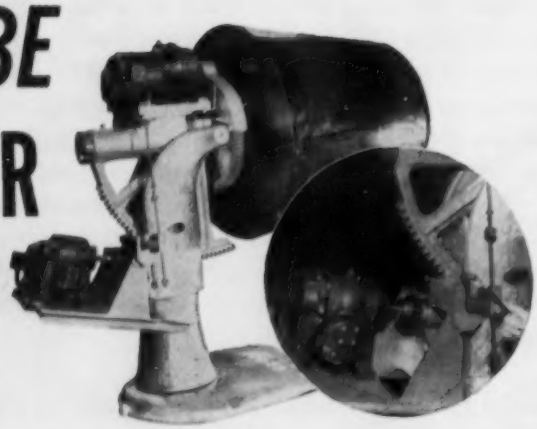
In high-temperature design, the standard safety factor of 1.5 is shown to have widely varied significance depending on how it is applied. Further study is urged to develop a practical safety criterion for materials used at high temperatures, and to investigate the whole field of engineering up to 1000° F.

G. F. Comstock

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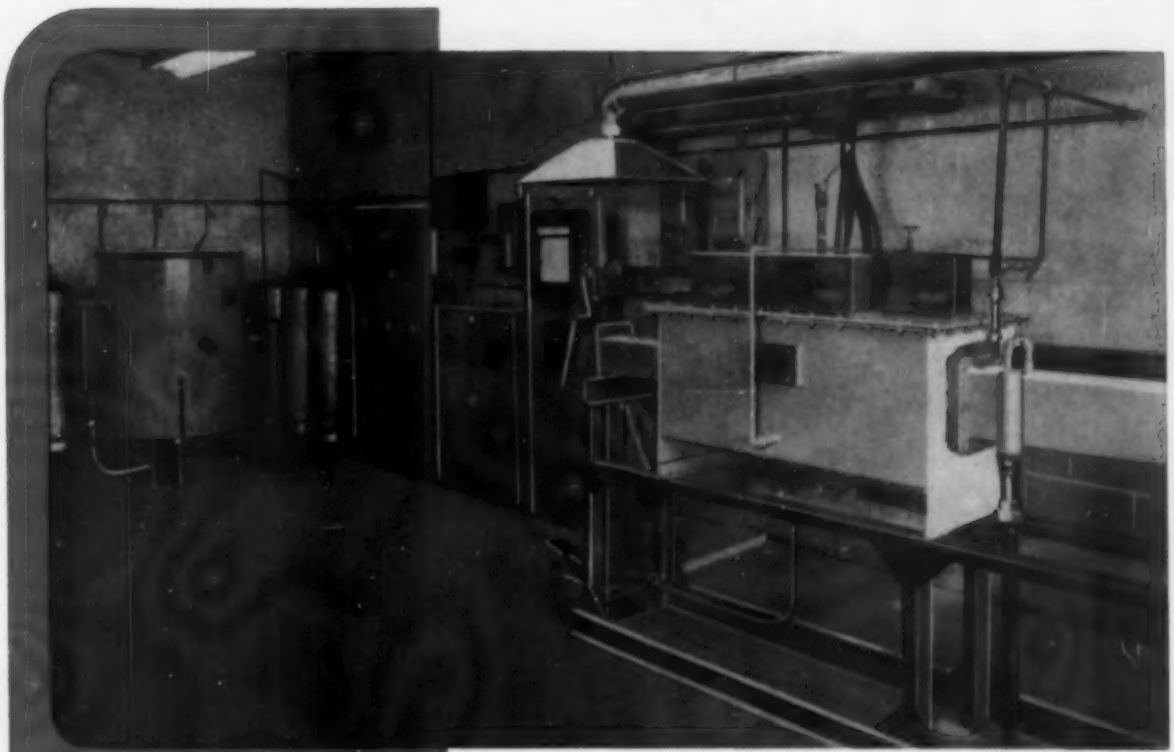
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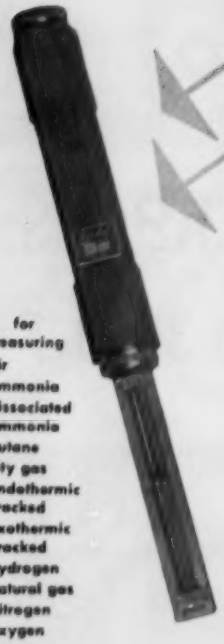
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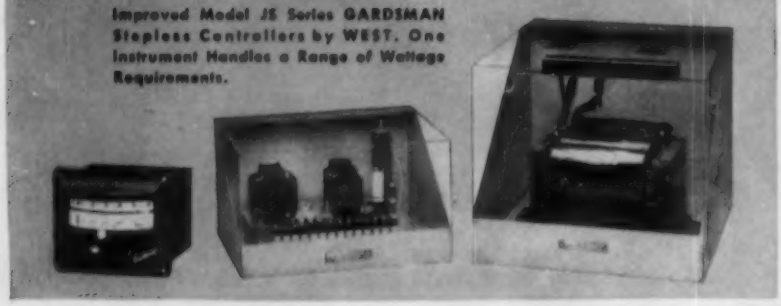
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Energy Criteria of Fracture*

At the 1953 Conference on Brittle Fracture Mechanics at Massachusetts Institute of Technology, Orowan presented some ideas on brittle fracture; the present article is an expansion of those remarks. The points of debate are the classical Griffith theory, Orowan's modification of this theory and certain problems incident to defining the conditions for brittle fracture in ductile steel.

In 1913, Inglis initiated the mathematical treatment which led to Griffith's classical publication in 1921 on the conditions governing crack propagation in a two-dimensional plate of ideally brittle material. His equation gave the critical stress as a function of Young's modulus, surface energy and crack length. Later studies showed discrepancies when this equation was applied to metal. X-ray back-reflection patterns of mild steel disclosed superficial layers of plastically deformed metal even on the facets of fractures classed as brittle. Estimates of the plastic work approximate 2×10^6 ergs per sq. cm. for fractures not too far below room temperature. Since by comparison the value for surface energy is negligible, Orowan has proposed replacing surface energy by plastic in the equation.

Griffith's equation simply indicates that a crack will propagate whenever the released elastic energy exceeds the requirements of surface energy in opening a fissure. Orowan then modifies this concept to account for the additional and much greater energy needed for plastic deformation.

Since the worth of the modification depends upon the validity of the original, Orowan next considers certain approaches taken by Föppl and Neuber which can be used to show that the stress concentration at the tip of a crack brings the Griffith critical stress to the approximate value of the molecular cohesion or theoretical strength, beyond which

(Continued on p. 236)

Digest of "Energy Criteria of Fracture", by E. Orowan, *Welding Journal*, Vol. 34, March 1955, p. 157s to 160s.



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Brittle Fracture . . .

fracture must take place. He regards his calculations as confirming the Griffith equation as a necessary and sufficient definition of the condition for fracture in a completely brittle specimen. The Orowan modification is then similarly accepted as both a necessary and a sufficient representation for a particular condition of brittle fracture in ductile steel – where the fracture velocity reaches values characterized by greatly reduced energy absorption and restricted prior plastic deformation.

On the other hand, the initiation and early history of such fractures will require further definition. For example, the Griffith type of equation shows that the tensile strength of a brittle material would increase toward infinity if the modulus were so increased, whereas plastic metals fracture at stresses related to the yield stress and quite independent of the modulus. Perhaps the most that can yet be said is that the onset of brittle fracture then seems to depend upon *(a)* the stress concentration factor at the crack tip and *(b)* factors such as fracture velocity which tend to raise the yield point reducing the gap between the values for plastic deformation and cleavage.

C. A. ZAPFFE



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(References for Article on p. 132)

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Turning Country Rock Into Iron Ore*

"BENEFICIATION", as used in this paper, includes any treatment that will improve the ore for blast furnaces or other metallurgical uses. Generally this means to increase the iron content, make it more reducible, enable the stock to descend more smoothly and produce less dust. This discussion thus includes crushing, concentration by washing or magnetic separation, screening, blending, and agglomeration by sintering or pelletizing for blast furnace use or for openhearth charging.

(One misses some mention of the separation in heavy media of the limonite ores at Birmingham, Ala., combined with sizing, blending and sintering of fines. Whereas 500 tons of pig iron per day was considered good performance in the Southern district 20 years ago, furnaces are now making 1200 to 1600 tons.)

The author spends much time on problems set by the taconite of the Lake Superior region, so intensively studied snce 1945 when the supply of direct shipping ores became dangerously low. Magnetic taconites containing 25.6% iron amount to 5 or 6 billion tons in the East Mesabi Range available for open pit mining; underground reserves to a depth of 1500 ft. total 20 to 30 billion tons. (Mr. Haven does not mention the even larger deposits of hematitic taconite in Minnesota, Wisconsin, and Michigan.)

Treated according to our present knowledge of beneficiation, the sinter (or pellets) will analyze:

	Taconite	Sinter	Pellets
Total Fe	31.00	64.25%	62.68%
P	0.04	0.023	0.023
SiO_2	45.00	9.05	8.28
Mn	0.60	0.22	0.19
Al_2O_3	0.70	0.42	0.38
CaO + MgO	5.40	1.48	1.35

Since the magnetite is so finely distributed in the taconite rock, fine grinding is necessary, and the concentrate is entirely unsuitable for blast furnace charge. In fact, even the fine Mesabi ores used in northern blast furnaces produce 250 to 500

(Continued on p. 240)

*Digest of "The Role of Iron Ore Beneficiation", by W. A. Haven, *Journal* of the Iron and Steel Institute, Vol. 180, 1955, p. 144.

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Iron Ore . . .

lb. of flue dust per ton of pig iron. After stockpiling this dust for many years, sintering plants were gradually installed to reclaim it and to agglomerate raw ore fines. Early sintering plants were very inefficient but improvements were slowly introduced such as sizing of the feed, accurate control of water content, control of fuel in the mix, and improvement in the machinery, thus increasing the output of greatly improved sinter from the original 500 up to 1800 tons per day. 4000-ton machines are being designed for sintering flue dust and raw ore fines.

These existing sintering machines did not work too well when fed the extremely fine magnetic concentrate. Fuel consumption was very high — about 1,800,000 Btu. per ton of product, and this fine coal or coke breeze cost at least $12 per ton delivered to the Lake ore districts. Rotary kilns for nodulizing also used much fuel and the product was of poor quality.

This situation has been cured by the "pelletizing" process long studied by E. W. Davis at the University of Minnesota. This consists of rolling the wet concentrate, mixed with a binder such as bentonite and a precise water content (8 to 10%) to form marbles or pellets about ⅝ in. diameter and then hardening such pellets by first drying and then baking them to about 2400° F. In this latter stage the Fe_3O_4 is oxidized to Fe_2O_3, an exothermic reaction which helps the heat balance and recrystallizes the iron mineral in the pellet. Probably some slagging reactions also occur.

Mr. Haven, the author, was long an executive of Arthur G. McKee & Co., and participated in the early engineering studies of the agglomeration problem. His company designed a nodulizing kiln with a capacity of 1000 tons per day and fuel consumption of 1,600,000 Btu., and a 1400-ton sintering plant with fuel consumption of 1,700,000 Btu. per ton. These pilot plants are still operating and the author observes, "Evidently agglomeration of taconites by both processes is commercially profitable."

The joint research work of McKee, Allis-Chalmers, Reserve Mining Co. and Erie Mining Co. is described in detail. Both mining companies are erecting huge taconite concentrators in Minnesota. The fine magnetic material is first pelletized at room temperature in "balling drums" wherein the overflow passes over a ½-in. screen and the undersize is recycled. Precise amounts of bentonite (4%) and water (8%) are added. The problem then becomes one of agglomerating and hardening the "green" pellets.

A pilot plant at Ashland, Ky., heated the raw pellets in a vertical shaft furnace fired with natural gas. Although satisfactory pellets were made which made a good blast furnace charge, the operation of the shaft furnace was extremely irregular, due to variations in the physical stability of the wet, raw pellets, slumping of the charge, and formation of clinkers at the outlet.

A second pilot plant at Carrollville, Wis., agglomerated the wet raw pellets on a sintering machine of new design. It was successful

(Continued on p. 242)

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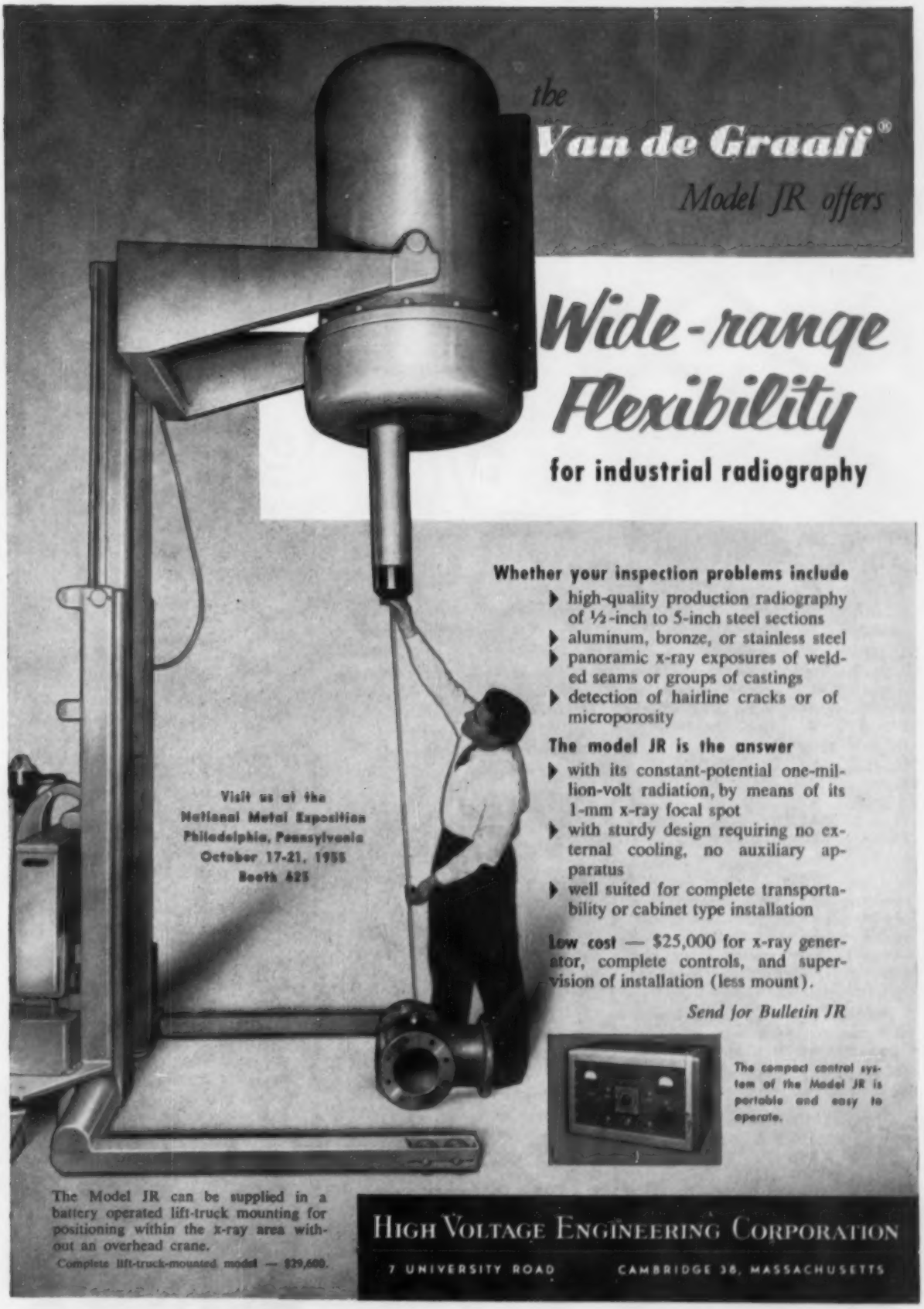
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Iron Ore . . .

enough to form the basis of the 1000-ton per day commercial plant of Reserve Mining Co. at Babbitt, Minn. This grate-type sintering machine, 6 ft. wide and 108 ft. long, has operated since February 1954 at an output above its rated capacity and has made very satisfactory pellets for both blast furnace and open-hearth charging, at a cost below that of foreign ore laid down at inland steel plants.

The sintering machine recirculates hot air, both up-draft and down-draft, by four fans and suitable ducts. The entering wet pellets meet an up-draft of hot air at about 750° F. which starts the drying operation. (This hot air comes from down-draft air cooling the fired pellets.) After drying, the pellets enter the next stage where additional hot air is down-drafted to ignite the fuel contained; after this the pans pass under the heating furnace with its separate down-draft fan. A temperature of 2400° F. is reached, which changes the magnetite entirely to hematite.

From the plants mentioned in this paper 830,000 gross tons of agglomerated taconite concentrates were shipped in 1954; of this, 150,000 tons were sintered direct, 300,000 tons were nodulized, and 500,000 tons were pelletized.

E. C. WRIGHT

Impact Tensile Test Clarifies Hot Working Properties*

A SIMPLE laboratory test to evaluate hot workability of metals and alloys has long been sought as the means of correlating many variables – for example, the effects of impurities in relation to heat treatment and working temperature. While such a test would not duplicate the actual mechanism of hot working, it would provide a measure of the ductility of the material under con-

(Continued on p. 244)

*Digest of "A Hot Impact Tensile Test and Its Relation to Hot-Working Properties", by E. A. Leech, P. Gregory and R. Eborall, *Journal of the Institute of Metals*, Vol. 83, February 1955, p. 347-353.



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Impact-Tensile Test . . .

trolled conditions from a single deformation. Conventional tests, such as tensile, notched-bar Charpy impact or high-speed torsion, do not provide quantitative data with good reproducibility.

A hot tensile-impact test, developed five years ago, appears to have interesting possibilities based on results of studies covering a variety of copper-base alloys, including brasses, bronzes and coppers with varying amounts of bismuth. The equipment consists of a flat bed plate, bolted and doweled to a block gripped in the recess of the Izod machine anvil by means of a separate wedge. A stationary jaw is fastened to the bed plate and is machined out in the center at one end to grip the test specimen. The specimen is 1.5 in. long, with a gage length of ⅝ in. machined to 0.3135 in. diameter.

The machine's striker bar straddles the stationary jaw and hits the protruding sides of the movable jaw at the level of the centerline of the specimen. The tensile-impact force is applied at a strain rate of 0.004 sec. A critical factor is the radius on the shoulders of the test piece; if it is less than 1/32 in. and ductility is low, the specimen is liable to fracture at this point.

The furnace used to heat the specimen is placed only a few inches from the anvil and the operation of removing test pieces from the furnace to place them in the jaws takes only 2 sec. or less. The technique is not entirely satisfactory where accurate temperature control must be exercised. For a copper-base specimen, the cooling rate is about 18° F. per sec. at 1290 to 1470° F. and the blow produces a rise in temperature of about 1.1° F. per ft-lb. absorbed.

Sensitivity of the test was checked by running three sets of bismuth-copper specimens at 1020° F. The energy to fracture and elongation measured on total gage length were highly reproducible. Results suggested that the test is best suited for rather brittle material. An obvious advantage is that two direct measures, elongation and reduction of area, are given, whereas the notched-bar impact test value is a function of both the amount of deformation before fracture and the force required to effect the deformation.

In corollary work, experiments were conducted to establish the relationship between ductility as determined in the hot tensile-impact test and edge cracking which occasionally occurs in hot rolling of strip. A series of tin bronze specimens was examined, containing 8% Sn and 0.1% P. Both cast and wrought material was tested after normalizing and one pass through a two-high roll stand at different temperatures.

Fairly good agreement was found with the formula developed by Bourne for the relationship between reduction causing cracking in cold rolling and the reduction in area at fracture in a tensile test. A ratio of 2 to 1, however, is suggested as more typical in hot rolling than the 4 to 1 proposed for the relationship in cold rolling.

A. H. Allen

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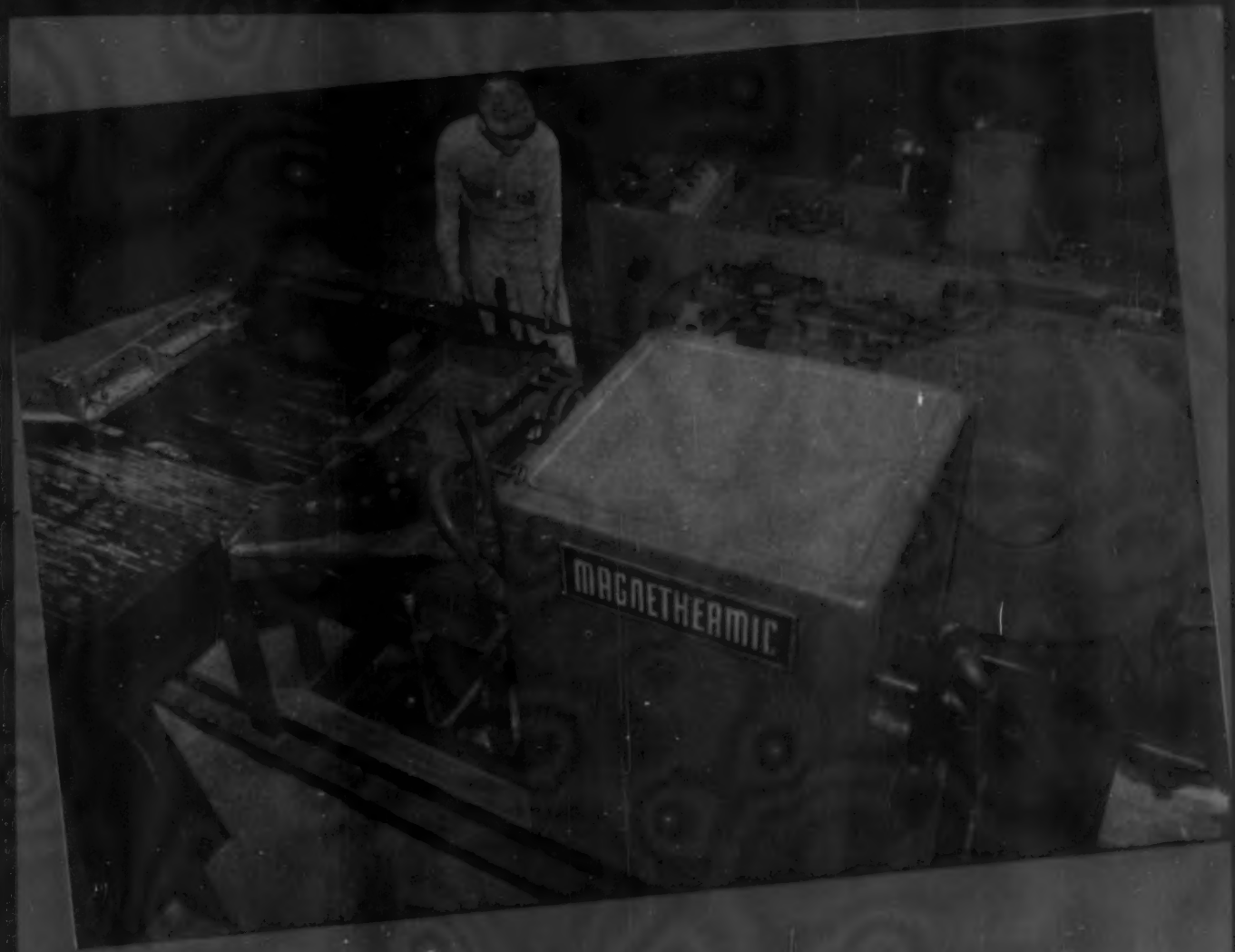
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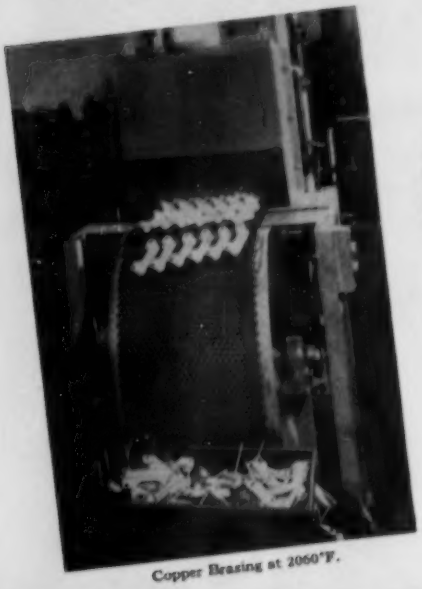
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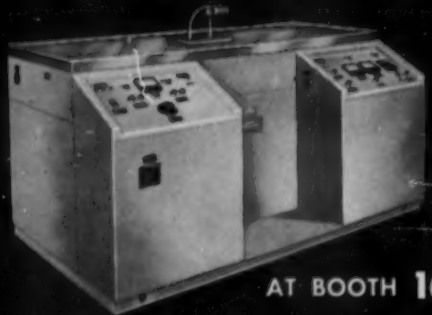
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Notch Effects on High-Temperature Alloys*

CREEP testing of notched specimens has been done at room temperature, and the results of these tests were relatively simple to interpret. However, as the test temperature and time were increased, particularly in more recent work in America, the interpretation became more complex. At the higher temperatures, diffusion and structural changes, such as the formation and disappearance of phases, can occur. The complexity of the problem increases with notched specimens.

There are essentially four factors that determine the rupture strength of notched specimens of high-temperature alloys in creep. These are the test temperature, time, notch geometry, and alloy composition. Other things being equal, the effect of time and temperature on, for example, the reduction of area at fracture is quite similar for notched and unnotched specimens in creep. If the reduction of area at fracture is plotted versus time for various test temperatures, the curves for both notched and unnotched specimens look like aging curves; a minimum ductility is observed after a certain time and this minimum increases while the time for reaching it decreases with temperature.

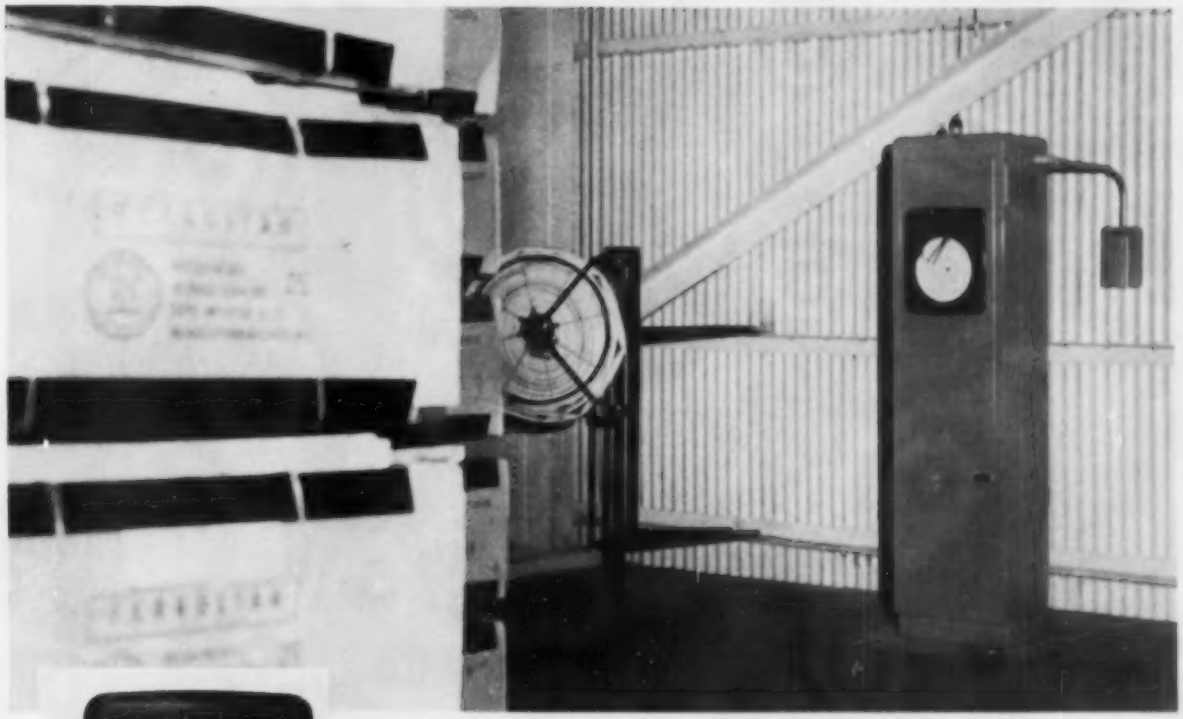
Evidently, structural changes in the alloy occur which may render it brittle regardless of whether there is a notch in it or not.

However, there is also a notch effect most clearly shown by plotting the notch-strength ratio (the ratio between the rupture strength of unnotched and notched specimens) against temperature or time. It is then seen that this effect also must be due to concurrent structural changes, for a maximum notch sensitivity is reached after a certain "aging' 'time. Generally the notch has little effect at high temperatures at which the alloy quickly "overages", or at low temperatures where "aging" generally cannot take place.

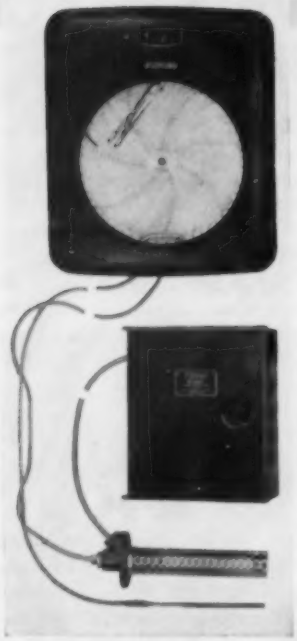
(Continued on p. 248)

*Digest of "The Effects of Stress Concentrations on the Rupture Strength of Materials Subjected to Creep Loading," by G. Sachs, D. P. Newman, and W. F. Brown; *Zeitschrift fuer Metallkunde*, Vol. 44, 1953, p. 233.

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Notch Effects . . .

It would be very desirable to be able to predict the creep behavior of a notched alloy from tests on the cheaper unnotched specimens. However, no precise relationship has yet been found. It can only be concluded that notch brittleness is highly unlikely for an alloy if its reduction in area at fracture is larger than 40% for an unnotched specimen, and if this value increases with time. On the other hand, notch brittleness is likely to be encountered if the reduction of area at fracture is less than 10% for an unnotched specimen and if this value decreases during long tests. No predictions can be made if the reduction of area of unnotched specimens lies between 10 and 40%. When notch brittleness *is* encountered, the rupture strength is generally low; this indicates that the notch sensitivity is the result of stress concentrations.

The effect of notch geometry has been studied on a few alloys. It seems that this effect is the same in creep as in ordinary tensile tests at room temperature. The notch-strength ratio is always larger than 1.0 for ductile specimens with notches as sharp as can be made. On the other hand, for less ductile, notch-sensitive specimens the notch-strength ratio first increases, reaches a maximum, and then decreases to values of less than 1.0.

The effect of composition has been studied for several families of alloys. Low-alloy Cr-Ni steels behave in about the same way as high-alloy ferritic stainless steels; in both a minimum of ductility is found. The time for reaching this minimum decreases with testing temperature. However, the amount of the notch sensitivity and the critical temperature range depend very much on the particular alloy. Too few data on austenitic steels are available to say clearly whether austenitic steels behave differently from low-alloy ferritic steels. Nickel and cobalt-base alloys have hardly been studied. It is known only that Inconel "X" is extremely notch-sensitive between 1300 and 1400° F.

There is a pronounced effect of structure. Notch brittleness is observed for some alloys when the heat treatment is changed slightly. For example, a low-alloy Cr-Ni-Mo steel is quite insensitive to notches after receiving a heat treatment that results in spheroidal cementite.

In addition to structural changes, cold work at room temperature can change notch brittleness in creep. If bars of certain austenitic steels are twisted at room temperature by increasing amounts prior to testing, they become more and more notch sensitive.

It seems to this reviewer that it would be very desirable to take a more fundamental approach to the problem of notch brittleness. Evidently, certain precipitated phases with proper size, shape, and distribution of particles cause brittleness, but it seems that no effort has been made to sort out the relative effects of these variables. Rather than making and testing new series of alloys, more progress might well be achieved if the effect of variations in microstructure on the notch sensitivity of one particular high-temperature alloy could be established.

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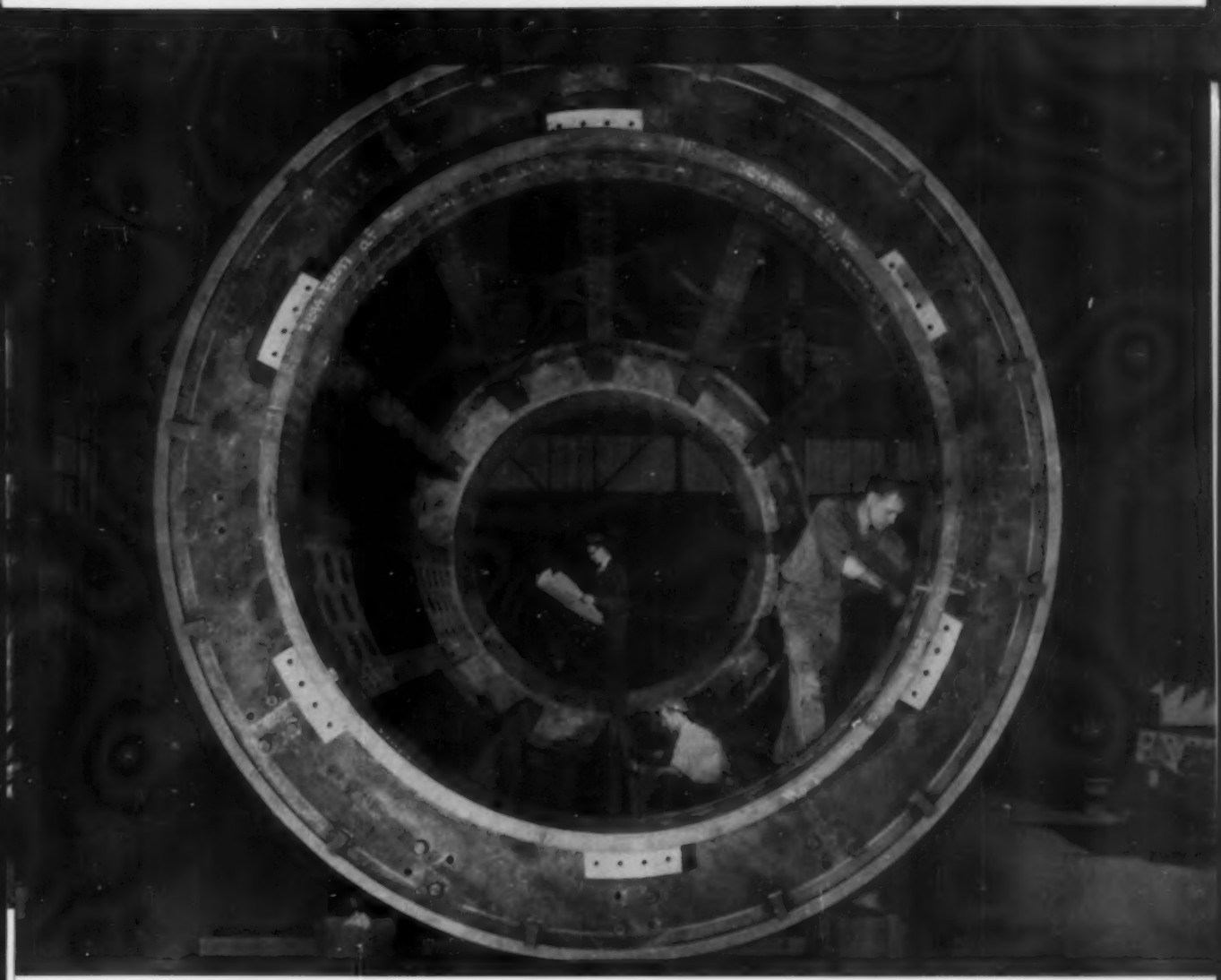
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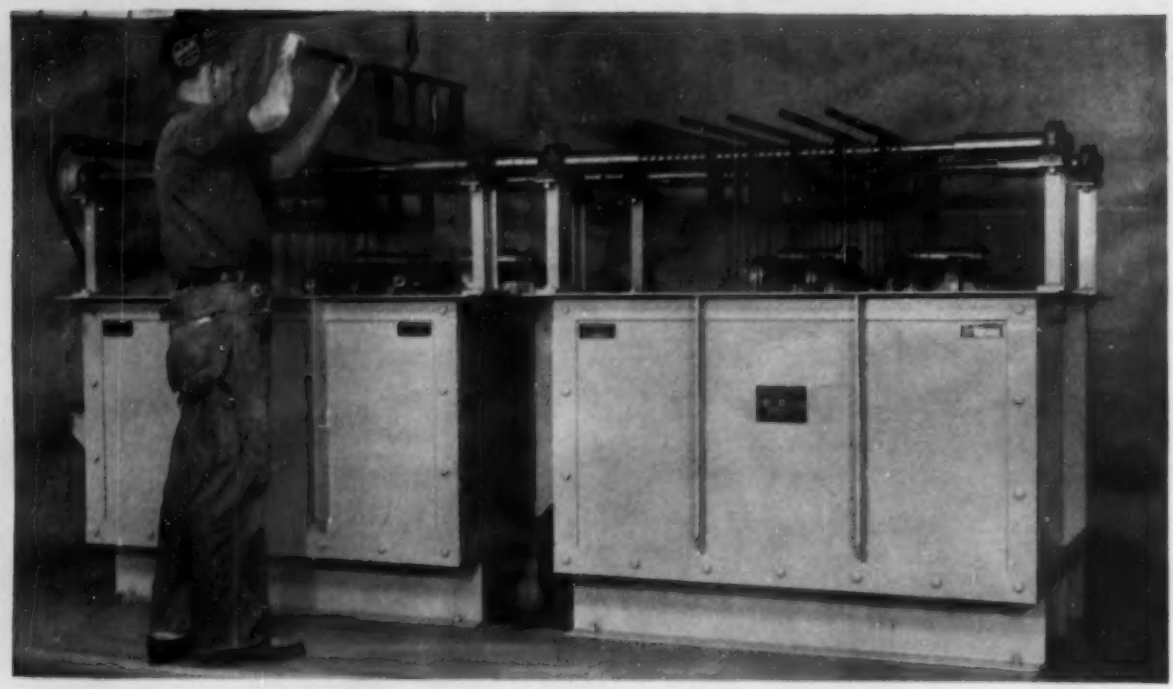
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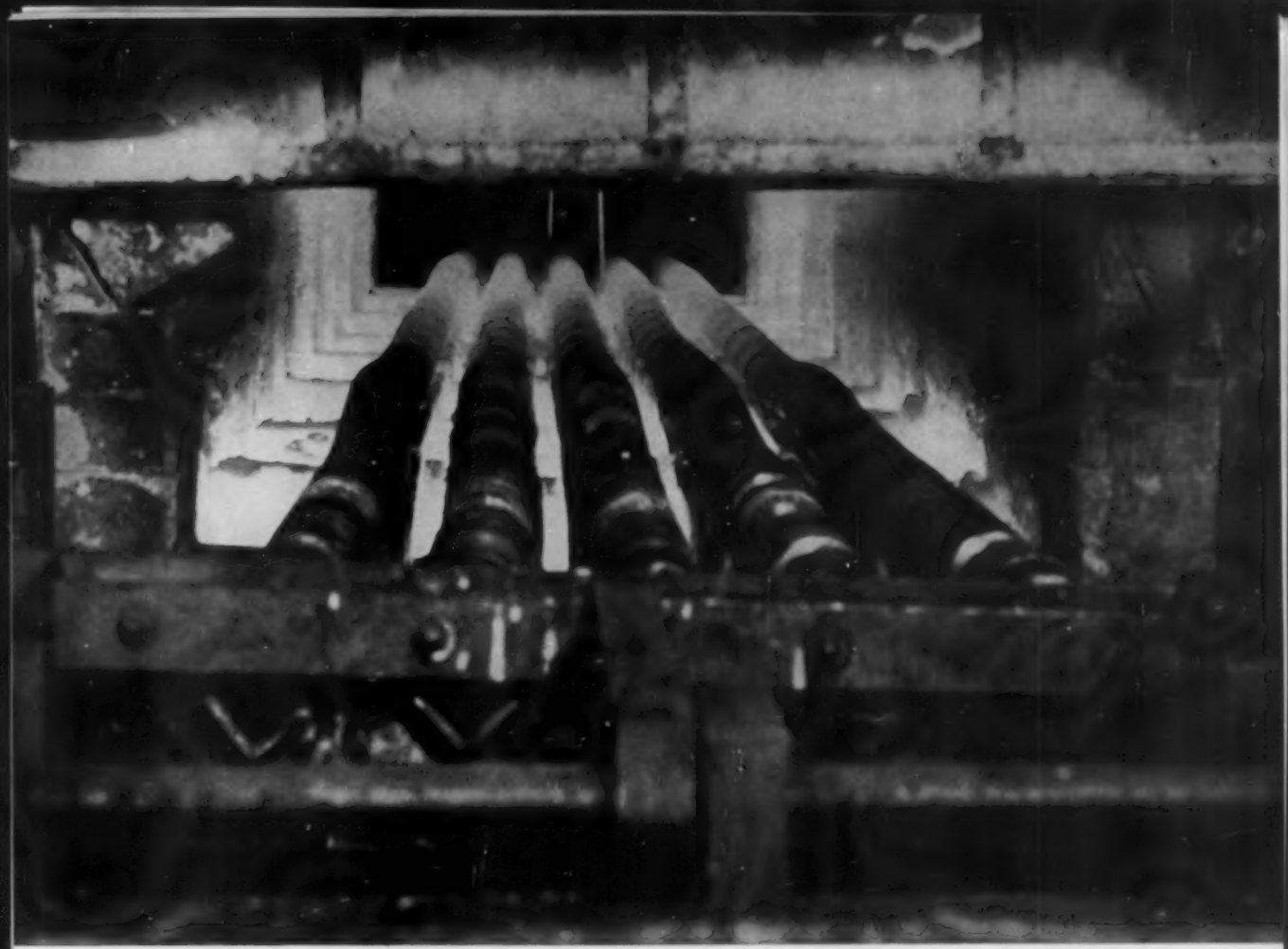
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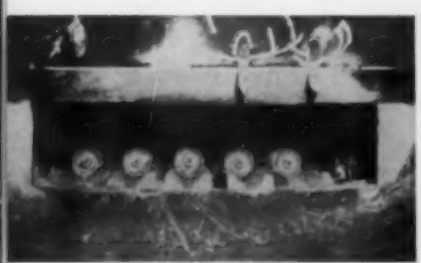
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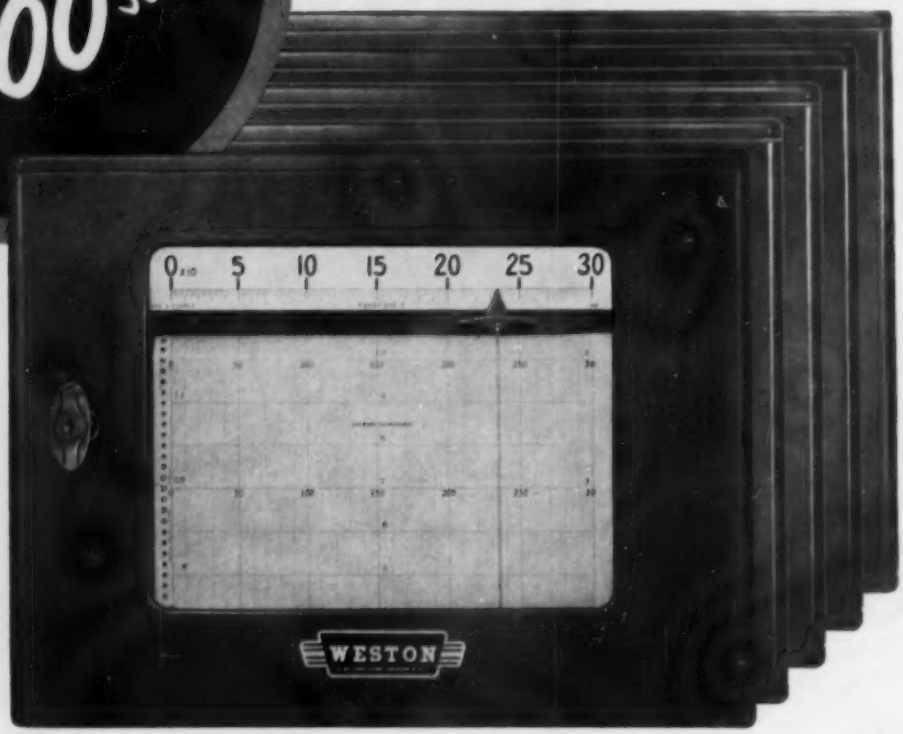
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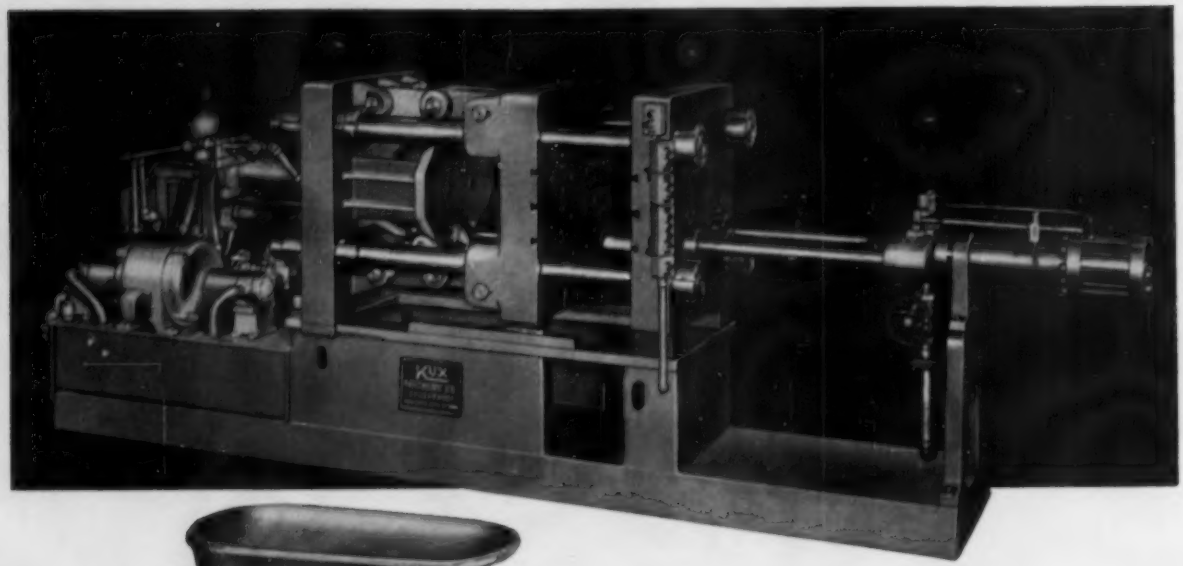
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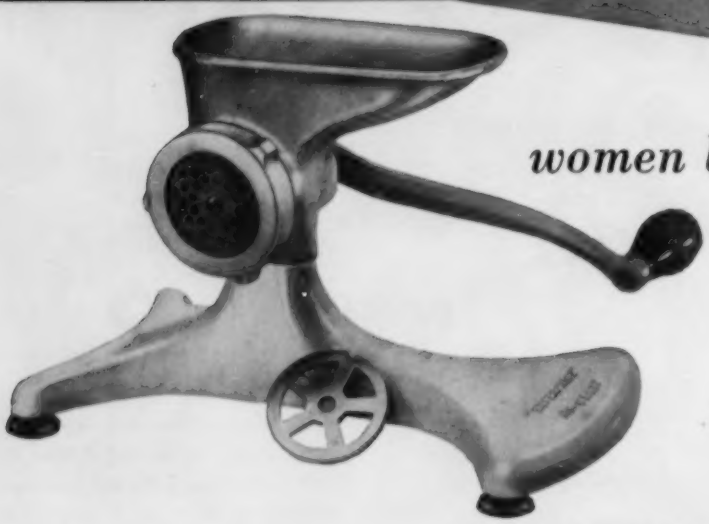
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"Kux machines give us the beauty of a hardware finish at an amazingly low cost per unit.

"We use them to cast aluminum tops for our *Home Aid* Freezer, and aluminum bases for our *No Clamp Chopper* and our *Shredder-Slicer-Grater.*

"Our engineering department selected the Kux machine primarily through recommendations of other firms using this machine," continues Mr. Sheeler. "The courtesy and service extended by the Kux people, in addition to the features of the multiplier, made our choice a certainty." (The exclusive patented Kux Multiplier increases the ending pressure up to five times the starting pressure, producing the most solid of die castings.)

Possibly your product can be redesigned to use die castings with a resulting increase in sales. Let KUX engineers give you the answer, or write for free illustrated catalog.

MODEL HP 37 ILLUSTRATED
Hydraulically operated die casting machine for production of aluminum casting weighing up to 10 pounds.

KUX MACHINE CO. 6725 NORTH RIDGE AVENUE • CHICAGO 26, ILLINOIS



Small diameter Inconel rod locks tray segments in position; eliminates structural welds and permits tray to expand and contract without undue stress. This Inconel tray is made by Misco Fabricators, Inc., 1999 Guoin St., Detroit 7.

Misco uses Inconel to triple life of gas carburizing fixtures

The tray you're looking at carries 30 pounds of odd-shaped baffles through 1650°F. . . . in a continuous furnace.

An oil quench follows . . . the entire heating and cooling cycle taking 11 hours.

At one time, fixtures were made of an alloy steel . . . and lasted only *three* months before failure from cracking and breaking.

Then Misco Fabricators, Detroit, switched to Inconel®. . . and the service life of the equipment was extended to *nine* months.

A 200 per cent improvement! But expected. For Inconel withstands severe thermal shock without spalling . . . sudden cooling without cracking. And has excellent resistance to reducing, carburizing or nitriding atmospheres.

By using Inconel fabricated equipment, the heat treater gets light, but rugged, fixtures . . . designed for his specific needs. And he gets strength and corrosion resistance at high temperatures.

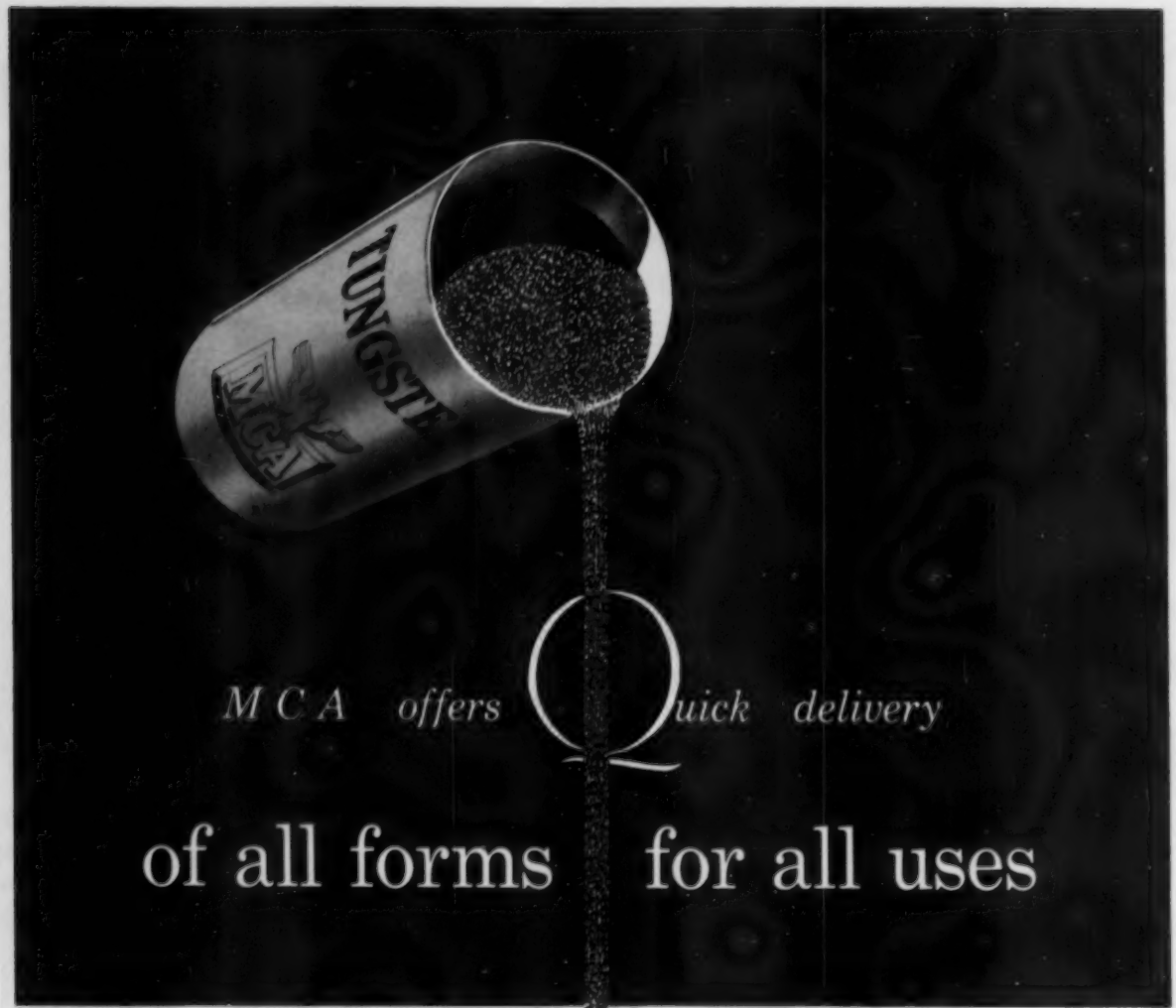
So, if heat isn't treating *your* equipment well you'll probably save your disposition and money by writing for our booklet "Keep Operating Costs Down When Temperatures Go Up."

The INTERNATIONAL NICKEL COMPANY, Inc.
67 Wall Street New York 5, N. Y.

Inconel

INCO TRADE MARK **Nickel Alloys**

. . . for long life at high temperatures



M C A offers Quick delivery

of all forms for all uses

TUNGSTEN

Ferro-Tungsten
Tungstic Oxide
Tungstic Acid
Ammonium Para-Tungstate
Sodium Tungstate
Tungsten Metal Powder

Now that Tungsten high-speed steel can be supplied as needed, manufacturers have returned to it for the well-defined uses in which it surpasses all other materials. Processed in the U. S. A., MCA Tungsten offers a consistently uniform product assuring excellent results.

As recognized authorities in the application of Molybdenum, Tungsten, Boron, Rare Earths, and the alloys and chemical elements of these materials, MCA assures confidential and immediate response to inquiries.

An informative book, entitled "Tungsten Steels", has been prepared by the Molybdenum Corporation. It deals with both scientific and practical considerations, and recommends procedures found to yield best results. A copy will be mailed on request.

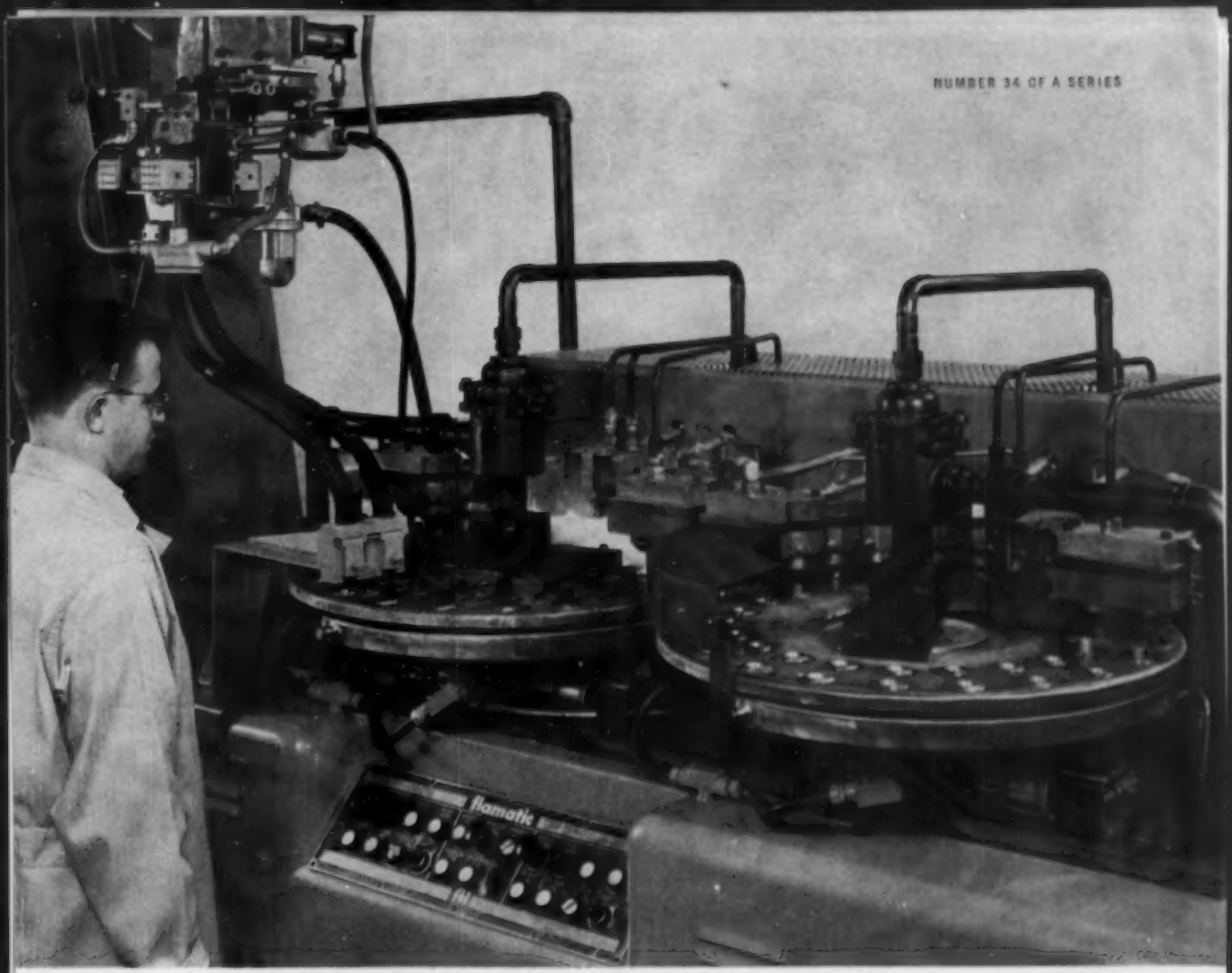
MCA

MOLYBDENUM

CORPORATION OF AMERICA

Grant Building **Pittsburgh 19, Pa.**

Offices: Pittsburgh, Chicago, Detroit, Los Angeles, New York, San Francisco
Sales Representatives: Edgar L. Fink, Detroit; Brumley-Donaldson Co., Los Angeles, San Francisco
Subsidiary: Cleveland-Tungsten, Inc., Cleveland Plants: Washington, Pa., York, Pa.



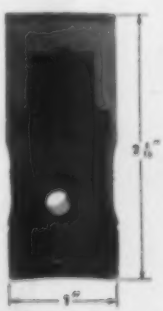
NUMBER 34 OF A SERIES

fully automated flamatic hardens 3600 parts/hour continuously

3600 hydraulic valve lifters per hour are continuously conveyed from a hopper to "carousel" type fixtures on this Cincinnati Flamatic hardening machine. The carousels index automatically after each heating cycle to bring a new pair of parts into position. Each lifter is selectively hardened to RC 57-61, to a ⅜" depth, and dropped into the oil quench. This is another demonstration that Cincinnati Flamatic engineers can match unusually high production rates and tight heating specifications by combining standard components with ingenious tooling.

Control cabinet, quench tank, and conveyor are standard, hopper-fed loading mechanism, turntables, and flame heads are special.

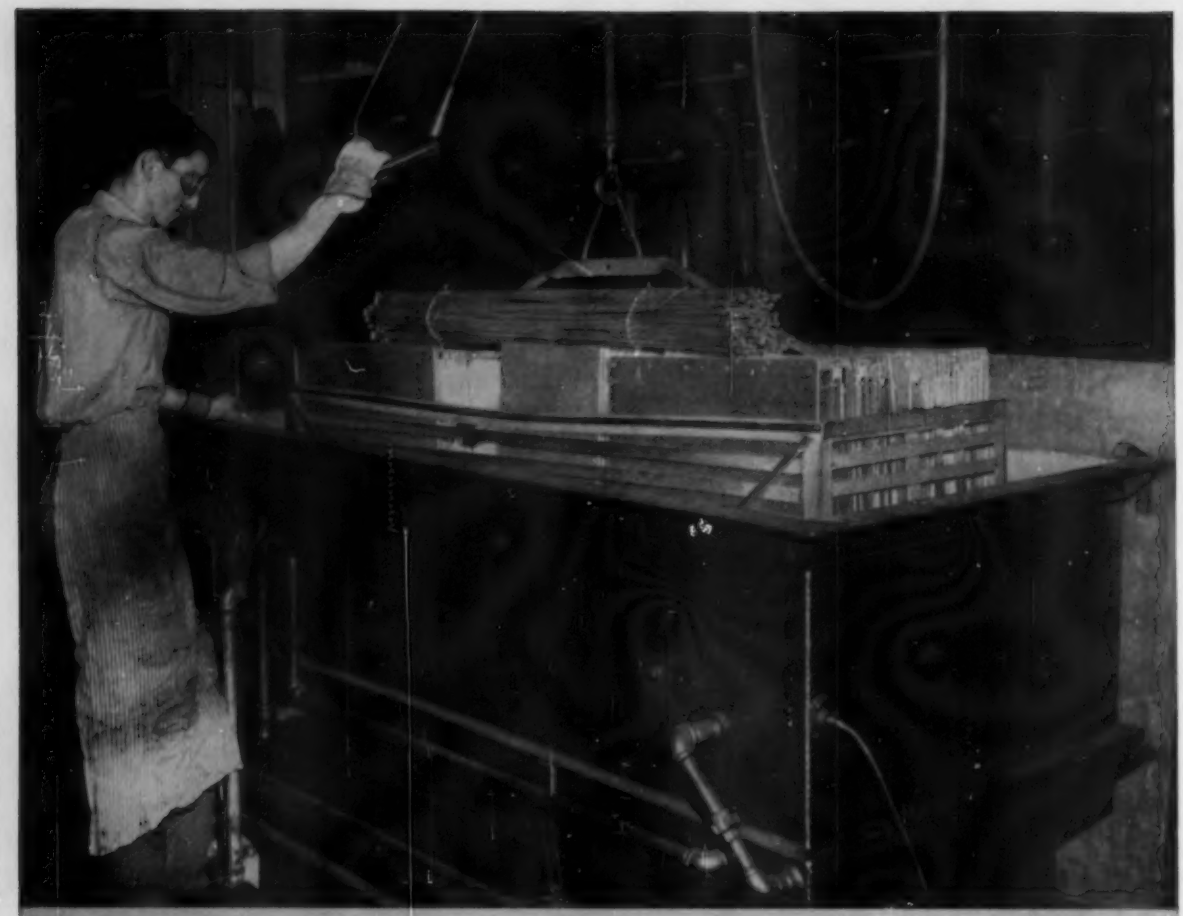
Look into Flamatic-hardening as a new approach to your heat treating problems. Bulletin No. 1861-M gives a wealth of good examples.



cross-section showing hardness pattern

CINCINNATI **flamatic**

PROCESS MACHINERY DIVISION
THE CINCINNATI MILLING MACHINE CO.
CINCINNATI 9, OHIO, U.S.A.



Want more cleaning at lower cost?

Use Nialk® TRICHLORethylene



Send for free illustrated booklet, NIALK TRICHLORethylene; *contains valuable data on the use and handling of this chemical.*

The high solvent power of NIALK TRICHLORethylene makes it one of the most efficient metal degreasing agents available today. This plus its recoverability for re-use proves it more economical for your cleaning and degreasing processes. Characterized by uniform quality and high chemical stability, this nonflammable solvent may be used in vapor degreasing or as a direct dip rinse.

Choose NIALK TRICHLORethylene for greater cleaning power per gallon.

NIAGARA ALKALI COMPANY

60 East 42nd Street, New York 17, N. Y.

Plant: Niagara Falls, N. Y.

H-VW-M RECTIFIERS

GERMANIUM and SELENIUM

For low voltage power rectification, H-VW-M's complete line of rectifiers answers your every requirement! High quality, top efficiency and unusual adaptability are only part of their product story; other outstanding advantages include economical operation, low maintenance, high power factor and low ripple.

Whether it's 6, 9 or even 48 volt output you require . . . whether your choice, based on economic considerations, calls for a selenium or the newly-developed germanium type of rectifier . . . you'll find an H-VW-M unit that will give outstanding service in providing a dependable low-voltage current supply to electrolytic processes. The types of voltage controls providing either smooth stepless or small incremental changes in output from zero to rated voltage make it an easy matter to obtain uniform deposits. Since H-VW-M supplies *both* rectifier types (and generators, too), you can be sure of an unbiased recommendation—the *right* recommendation for your installation. Check the features of these two advanced H-VW-M types—and see how an H-VW-M Rectifier fits into your power picture.

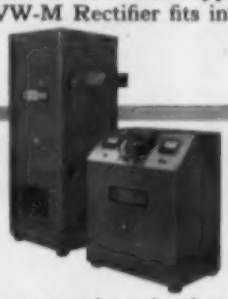


NEW H-VW-M GERMANIUM RECTIFIERS

Designed for 24-hour-a-day service at full capacity, H-VW-M Germanium Rectifiers have numerous voltage ratings from 12 to 48 volts for standard units and an even wider range for special units. Current outputs are from 1000 amperes up. Principal features of the germanium junction are its very low voltage drop, high inverse voltage rating, and very small reverse current.

- **Outstanding efficiency and voltage regulation** — Greater than 90% efficiencies at full load. Voltage regulation better than ± 5% from no load to full load without special additional controls.
- **Several types of controls** — Single wheel manual tap switch, motor-driven tap switch, or motor-operated, oil-immersed, continuously variable auto-transformer controls — whichever fits the plating requirement most economically.
- **Cooling** — Simple forced air cooling by sturdy updraft fan mounted in top.
- **Electrical protection** — Safeguarded from overloads and DC line shorts by replaceable link-type fuses in the output circuit; thermal overload switch and magnetic contactor complete the protection.

Write for Bulletin GR-100



H-VW-M SELENIUM RECTIFIERS

For voltage output requirements ranging from 6 to 48 volts, from 15 amperes and up — bench, self-contained, or remote controlled. Economical, efficient, dependable, and simple to operate.

- **Greater effective selenium plate area per ampere** — Limits rise in stack temperature to insure long life.
- **Electrically balanced selenium plates** — Only electrically identical plates are assembled into same stack for greater efficiency and durability.
- **Corrosion protection** — Special fungus and moisture proof coating guards against deterioration of stacks and transformers.
- **Adaptability** — Auto-transformer in regular units can be used for either 220 or 440 volt input.
- **Electrical protection** — Complete overcurrent and undercurrent protection. Thermostats guard against overheating.
- **Forced air cooling** — Same efficient cooling system as in germanium rectifier cools both selenium stacks and transformers, adds safety.

Write for Bulletin ER-107

There's an H-VW-M unit to cover *every* DC low-voltage requirement. One more reason why — when it's a question of equipment or supplies — the metal finishing industry always thinks of H-VW-M first!

PLATEMANSHIP

Your H-VW-M combination—of the most modern testing and development laboratory—of over 80 years experience in every phase of plating and polishing—of a complete equipment, process and supply line for every need.

HANSON-VAN WINKLE-MUNNING COMPANY, MATAWAN, N. J.

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instrument adaptability

WITH SPEEDOMAX® H

● Whether you melt metal, refine chemicals or bake bread, there's a Speedomax H available for the job.

For this complete line of electronic temperature instruments is being quantity-produced from a series of standard, integrated components.

Null-balance potentiometer indicators or indicating recorders . . . with either round or strip charts . . . can be combined with the type of control action best suited to your process needs. Whether you need simple or multiple action control . . . instrument and control components come to you as one integral unit.

And all proportioning control chassis are interchangeable. You can select the instrument to fit your process now, and at any time modify it to meet new conditions . . . quickly and economically.

To see the features of this unique instrument, get our pictorial fold-out which takes you inside Speedomax H. Just phone your nearest L&N office or write us at 4927, Stenton Ave., Phila. 44, Pa. Ask for Die-Out ND46(1).



LEEDS & NORTHRUP
instruments — automatic controls • furnaces

Controlled...every step of the way

VANCORAM FERROCHROMIUM





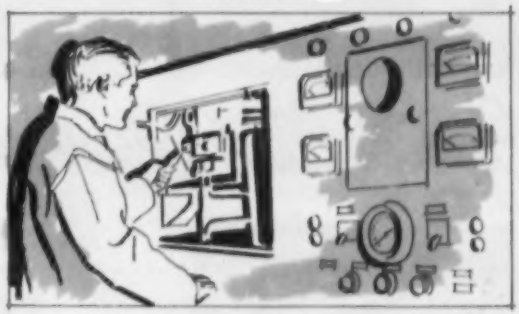
MINING



MILLING



SMELTING



RESEARCH

The high-quality standards for which Vancoram Ferrochromium is well known are made possible by complete integration and careful control of every step of the process, from mine to finished product.

To insure our customers a steady and continuing source of supply, we have stepped up the expansion and development of high-grade metallurgical chrome ore at our mines and mills.

There is a type and grade of Vancoram Ferrochromium for every application... stainless steels, tool steels, constructional alloy steels—and for use by the iron foundry. VCA's experienced Research and Technical Service Staff is working constantly at our modern Research Center, at our plants and in the field to improve product quality and to help customers in the proper application of Vancoram products to their processes.

Call your nearest Vanadium Corporation office for prompt, efficient service.

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Producers of alloys, metals and chemicals

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Controlled Quenching FOR BETTER PRODUCT



Battery of B & G Quench Tanks served by B & G Oil Cooling System illustrated above.

The above illustration typifies the quenching methods employed by modern metal fabricating plants to protect the quality of their products.

Here a battery of B & G *Hydro-Flo* Oil Coolers is employed to keep quench oil constantly at a predetermined temperature. By controlling quenching conditions, uniformity of product is assured.

B & G *Hydro-Flo* Self Contained Oil Coolers are complete packages... combining Coolers, Motors, Pumps, Strainers and all controls into single, integrated units. Fully automatic, they keep oil temperature at the desired degree through all stages of the quench.

Or, if you prefer, the component parts of a B & G *Hydro-Flo* Oil Cooling System may be purchased and assembled on the job. B & G Quench Tanks are also available... either in standard designs or built to your specifications.

Send for Catalog and Simplified Selection Manual.

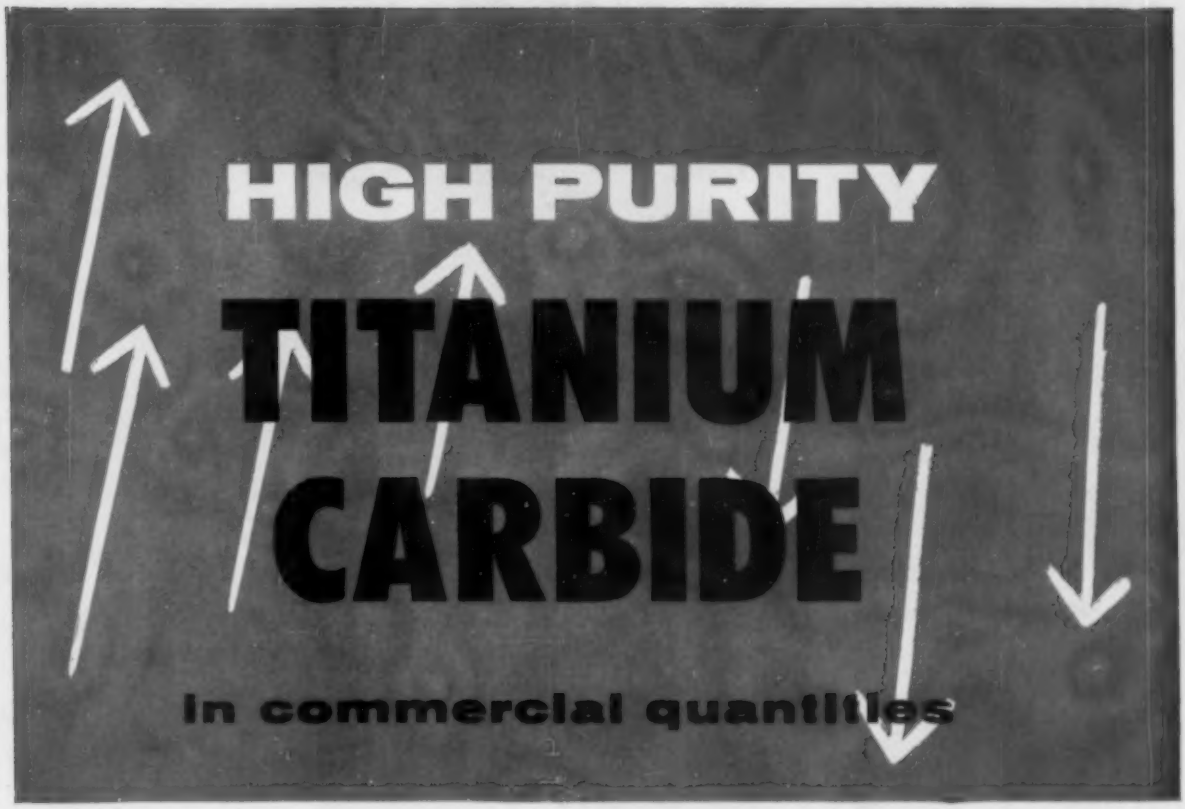
Hydro-Flo* **OIL QUENCHING SYSTEMS**

BELL & GOSSETT COMPANY

Dept. EE-16, Morton Grove, Ill.

Canadian Licensee: S. A. Armstrong Ltd., 1400 O'Connor Drive, Toronto

*Reg. U.S. Pat. Off.



TITANIUM CARBIDE is an extremely hard substance with good oxidation resistance at high temperatures. This combination of properties makes its use advantageous in several applications. Among these are **1.** as a component in sintered steel cutting tools, **2.** for jet engine parts and **3.** as a high temperature refractory material.

PROPERTIES

Structure . . . cubic — **Hardness** . . . . . 9 Moh scale
Mp . . . . . 5680°F — **Mesh Size** . . . . 95 to 98%-325

(also finer particle sizes 10 microns max. and 5 microns max.)

ANALYSIS of current commercial production of TAM* Titanium Carbide shows this high purity:

Combined Carbon . . 19.0% Min. — **Ti** . . 79.0% Min.
Free Carbon . . . . . 0.3% Max. — **Fe** . . 0.2% Max.

AS A DEVELOPER of metals, alloys, chemicals and compounds of both Titanium and Zirconium . . . TAM* is experienced and equipped to serve your needs for these products.

*TAM is a registered trademark.

FOR COMPLETE INFORMATION **TAM** WRITE OUR NYC OFFICE

Registered U. S. Pat. Off.

TITANIUM ALLOY MFG. DIVISION
NATIONAL LEAD COMPANY

Executive and Sales Offices: 111 Broadway, New York City
General Offices, Works and Research Laboratories: Niagara Falls, New York

WHEN PARTS ARE CAST FOR A TOUGH ROLE



25-lb. plating work carrier cast in high-conductivity beryllium copper and used in plating equipment made by The Udylite Corporation.

THEY'RE MADE OF BERYLCO® BERYLLIUM COPPER

The increased amperage called for in modern plating equipment demands higher conductivity in this casting—a contact which rides on a copper bus bar and transmits current from the bar to the plating tanks. Various materials used in the past, although they had the required wear resistance, lacked the conductivity for this application. To get around the problem, engineers considered brazing a strip of high-conductivity "Berylco" beryllium copper to the part.

Our engineers recommended that instead the whole part be cast in "Berylco." The solution was ideal. "Berylco" not only combines high conductivity with high strength and remarkable wear resistance, but is also a very good casting alloy. Pouring temperatures are low, fluidity is excellent, and needed detail can be sharply reproduced. Most important, cost is competitive.

What do you expect an alloy to deliver? Fatigue resistance? Corrosion resistance? Strength? Conductivity? Elasticity? Workability? "Berylco" beryllium copper fills these and many other roles as no other alloy can. Write any of the offices listed below for free testing samples or technical assistance.

DOZENS OF APPLICATIONS



for "Berylco" beryllium copper are discussed in detail in this informative 32-page booklet. Send for your free copy today.

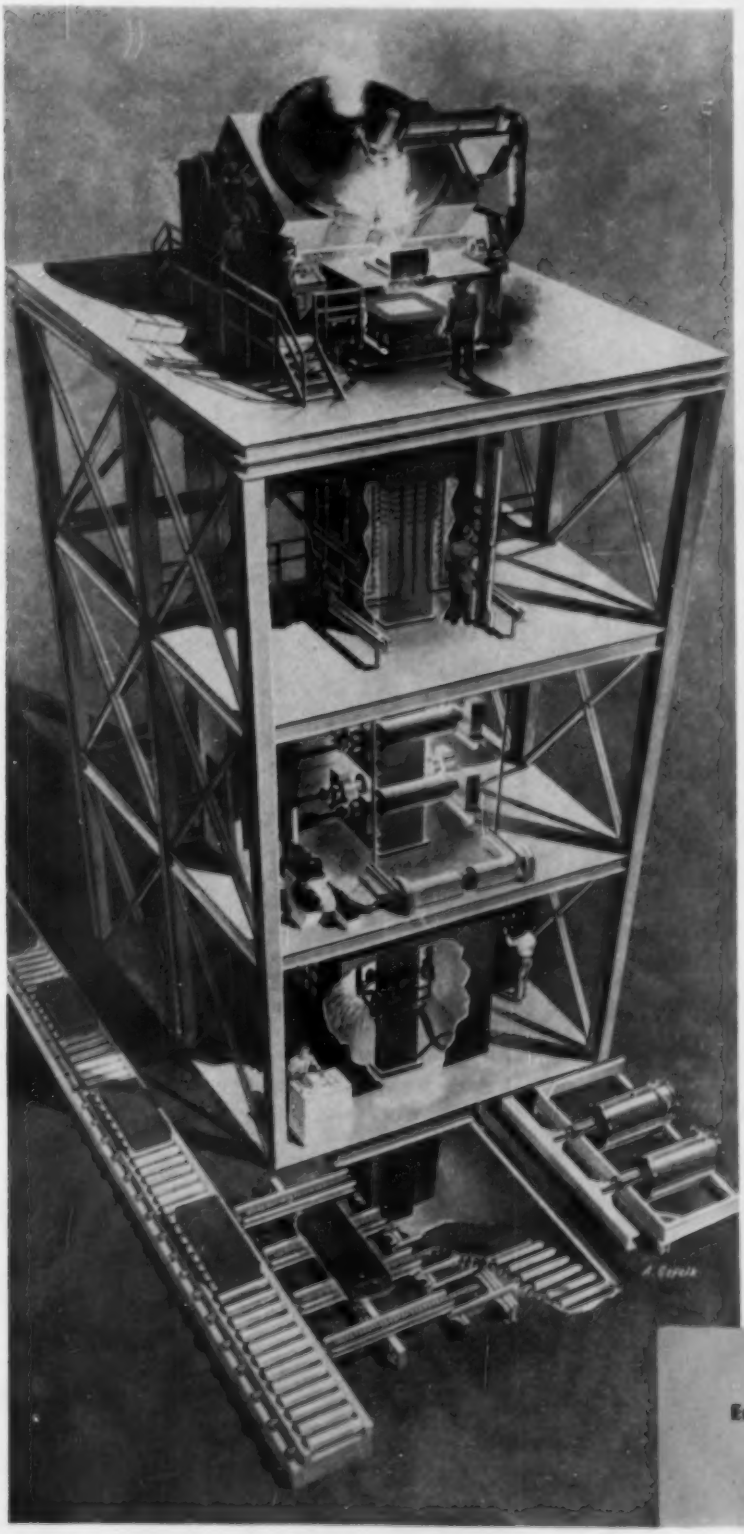
Tomorrow's products are planned today—with "Berylco" beryllium copper

THE BERYLLIUM CORPORATION

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For the continuous casting of steel...



Koppers builds the first commercial-scale machine

The continuous-casting machine illustrated here is now in operation at Atlas Steels Ltd., Welland, Ontario, Canada. This is the first commercial-scale installation in North America that, in a continuous line, converts molten steel into solidified billets or slabs. It was designed and constructed by the Freyn Department of Koppers Engineering and Construction Division.

Atlas Steels' machine is presently producing slabs and billets in three sizes. With different molds, this machine also could produce any desired billet section. It is designed to cast 35-ton heats.

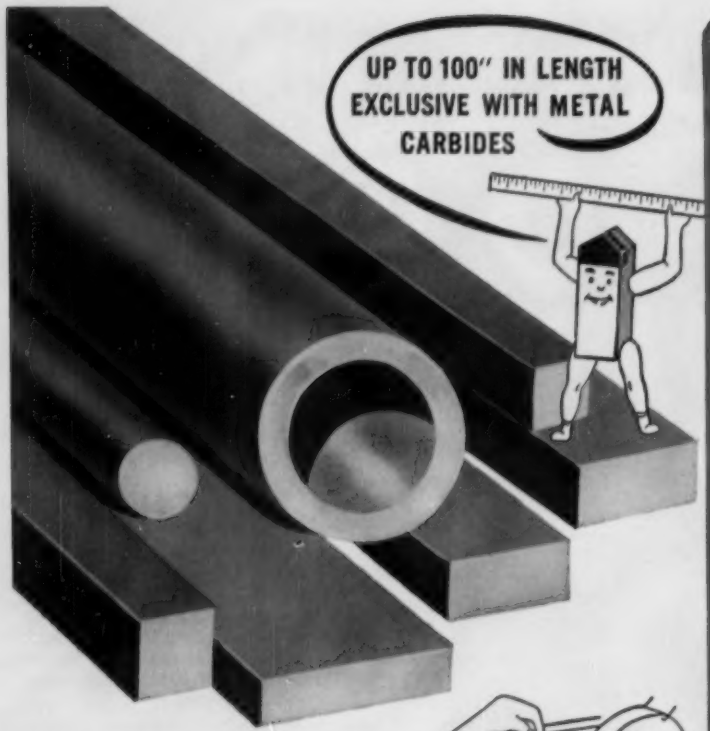
In theory, this new machine could cast a billet or slab of steel many miles in length; it is limited only by the supply of molten metal. In actual practice, acetylene torches automatically cut the molded steel into re[illegible] lengths as it emerges from the machine.

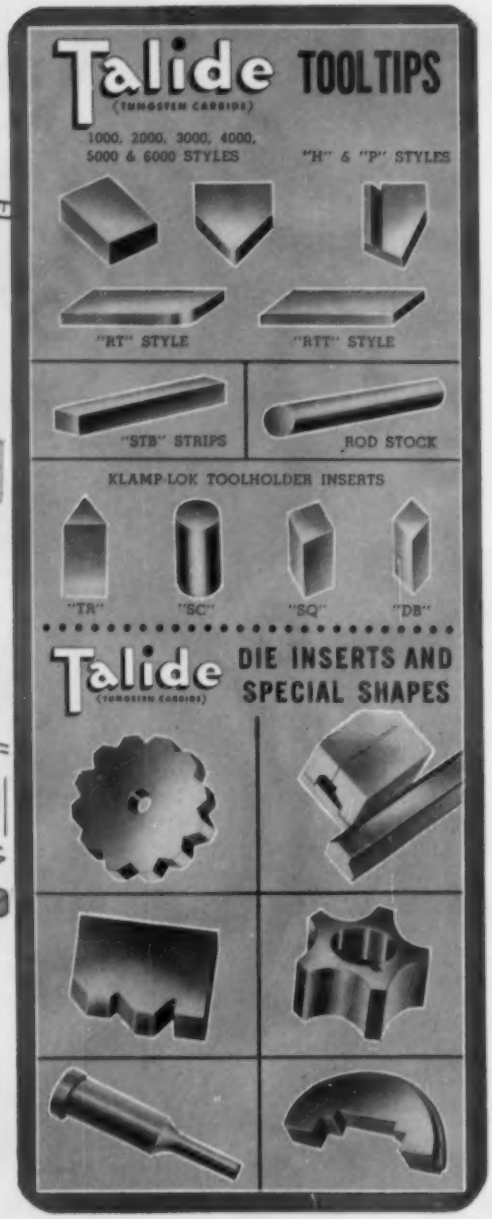
Continuous casting is an *economical* short-cut in steelmaking. It eliminates the need for ingot-casting and stripping equipment, except the ladle crane. Soaking pits and blooming mills can be by-passed. Also, the Freyn-design continuous-casting process can yield 10 to 15 per cent more finished steel per heat than conventional pouring methods.

Your inquiry is invited concerning the continuous-casting operation . . . or any other metallurgical construction problems you may have. You incur no obligation.

KOPPERS®

KOPPERS COMPANY, INC.
Engineering and Construction Division
FREYN DEPARTMENT
Pittsburgh 19, Pennsylvania







first to offer

carbide bar stock cut to length

Now you can buy super hard **Talide Bar Stock** in bars, strips or rods; in standardized sizes from 1/16" square to ¼" x ¾" rectangular; tubes 1/16" to ⅜" O. D.; rods 1/16" to ½" diameter . . . IN ANY LENGTH. Complete stocks are available at these warehouses:

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Youngstown, O. . . . . 107 E. Indianola Ave.
Chicago, Ill. . . . . 4244 W. Diversey Ave.

Metal Carbides stocks 1325 different sizes of standard, solid Talide Metal in bars, strips, rods, tubes, bushings, rings, flats, tips and discs for immediate shipment. Special shapes furnished up to 25" O.D. in any length and up to 5000 lbs. per piece by weight —for every die and wear part application.

● Metal Carbides produces only top quality metal in latest type vacuum furnaces. From ore to finished product, all operations are rigidly controlled in our new multi-million dollar plant of over 100,000 sq. ft. Write for Catalog 55-G. Metal Carbides Corporation, Youngstown 7, Ohio.

Only Metal Carbides Produces both Sintered and Hot Pressed Carbides





WE DON'T STOP WITH THE DELIVERY OF A CHEMICAL—
we put it to work and keep it working effectively

The chemical treatment of metals and metal parts—to prepare them for further processing, to protect them, to beautify them—has grown from a haphazard operation to a highly technical one. Supplying the chemical ingredients is a relatively simple job. Putting them to work and keeping them working effectively in your plant demands the skill of an experienced organization. We have that organization.

We supply not only the metal-treating chemicals, but also—free of charge—the technical and engineering service to keep them working at top efficiency. We furnish assistance in developing and installing the process, we maintain continuing inspection of the process and equipment if you so desire, we check samples of the processed metals in our Quality Control Laboratories—all these are part of the ACP service at your command.

That's why we say, "We don't stop with the delivery of a chemical—we put it to work and keep it working effectively." And we have been doing this for over 40 years. Write for a booklet describing ACP products and services.

AMERICAN CHEMICAL PAINT COMPANY, Ambler 16, Pa.

DETROIT, MICHIGAN NILES, CALIFORNIA WINDSOR, ONTARIO

CHEMICALS ACP PROCESSES

DOW



airborne hangar for the Marine Corps

. . . *made of Magnesium*



The U.S. Marine Corps called for a very particular metal for the framework of a very unusual "flying hangar." This metal had to be:

- Light enough to be carried, completely assembled, by a helicopter.
- Strong enough to withstand the repeated takeoffs and landings.

Magnesium, with its high strength/weight ratio, was the answer. Matter of fact, magnesium is appearing in more applications every day where light weight and simplified design are important.

Follow the Marine Corps—take a new look at magnesium! Call your nearest Dow sales office for more information or write to THE DOW CHEMICAL COMPANY, Midland, Michigan, Dept. MA 313F.

you can depend on DOW MAGNESIUM

DOW



Are You Aware of the Exciting Opportunities for Product Improvement that Exist Now?

Today, industry is forging ahead in the development of products little dreamed of only a few short years ago.

Instrumentation . . . miniaturization . . . more automatic production . . . all are demanding parts and components with new operating advantages. And High Nickel Alloys are playing an important part in meeting the needs. Are *you* aware of the opportunities High Nickel Alloys offer? For example, do you know you can . . .

. . . Design smaller, lighter weight units through the use of "extremely sensitive" alloys that respond to very weak electrical currents?

. . . Assure precision product performance with the help of an alloy that exhibits infinitesimal size change through temperature ranges up to 400°F?

. . . Compensate a given magnetic field for temperature changes to insure consistently accurate product performance?

And the list goes on . . . an exciting list of properties that can lead to rewarding fields of new and improved products!

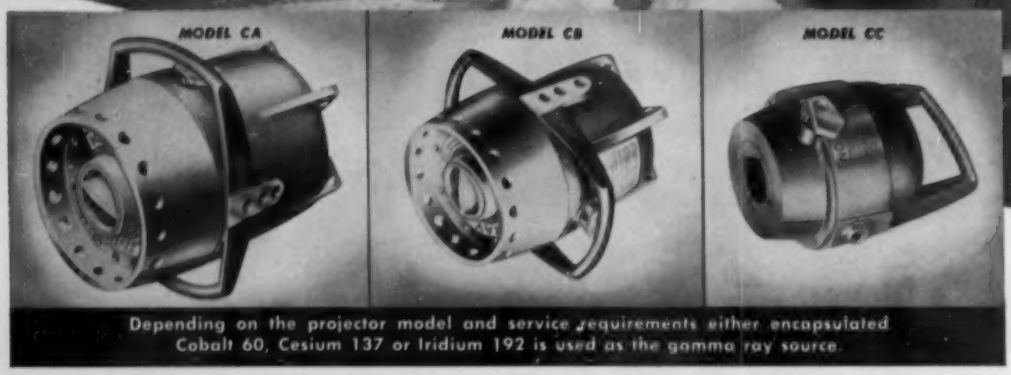
Getting High Nickel Alloys to do special jobs for you . . . making them behave in the way *you want them to behave* . . . is an opportunity we welcome. By making a team of your engineering experience and Carpenter's ability to produce closely controlled High Nickel Alloys with predetermined behavior, you often take an immediate step to product improvement. To help you in this job, Carpenter manufactures an unusually complete line of High Nickel Alloys . . . Temperature Compensator, Low Expansion, High Permeability and Glass Sealing Alloys. These are available in the largest variety of forms including strip, wire, bars, tubing, forging billets, etc. Ask for detailed engineering and application information. A note on your company letterhead is all that's necessary.

Carpenter STEEL — **High Nickel Alloys**

Pioneering in Improved Tool, Alloy and Stainless Steels Through Continuing Research
THE CARPENTER STEEL CO., 133 W. Bern St., Reading, Pa.
Export Department: The Carpenter Steel Co., Port Washington, N.Y.—"CARSTEELCO"

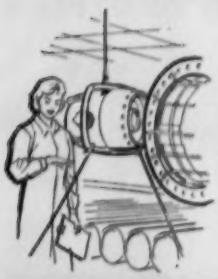
presents the KEL-RAY® Projector

A safe versatile tool for Radiography with gamma rays . . .



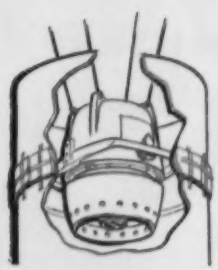
Depending on the projector model and service requirements either encapsulated Cobalt 60, Cesium 137 or Iridium 192 is used as the gamma ray source.

NON-DESTRUCTIVE INSPECTION and TESTING



SAFE

KEL-RAY projectors have extremely low radiation leakage. . . so low they can be shipped and stored without additional shielding. They are tamper, fire, and shock proof. Operated under prescribed procedures, leakage is below the AEC limit.



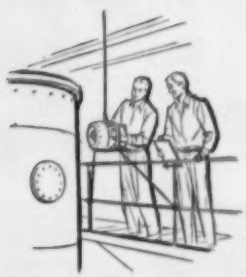
VERSATILE

A single set-up can produce either spot, doughnut, or hemisphere panoramic radiographs. Thick steel sections can be radiographed; sensitivity is so great even incandescent lamp filaments have been radiographed with a KEL-RAY projector.



CONVENIENT

Designed for field or shop use, the smallest model can be carried by hand—largest is transported and positioned speedily with standard equipment for materials handling and rigging.



ECONOMICAL

Initial and operating costs are low. No delicate parts to pamper or adjust . . . no expensive electrical power source required. Minimized overall set up and exposure time provide further savings.

Each of the three KEL-RAY Projector models is a portable, powerful, shielded, self-contained source of penetrating radiation for non-destructive inspection in maintenance, construction or quality control. There is a KEL-RAY Gamma Ray Projector that can improve your operations —save you time and money! Write for detailed literature.

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*Sold exclusively by Metal & Thermit Corporation. Designed and manufactured by The M. W. Kellogg Company.

METAL & THERMIT CORPORATION

100 EAST 42nd STREET • NEW YORK 17, N. Y.



SUPERIOR TUBING acts as a temperature and mechanical handling shield for delicate sub-surface, radioactive logging instruments.

SMOOTH SURFACES, CLOSE TOLERANCES, LIGHT WEIGHT: REASONS WHY SUPERIOR TUBING IS USED TO HOUSE THESE DELICATE WELL SURVEYING INSTRUMENTS

Well Surveys of Tulsa, Okla., purchases Superior Seamless Type 304 Stainless Tubing in large OD, light wall sizes and in 63 in. lengths. Into these tubes, which in the finished state vary from 28 to 31 in., radioactive well-logging instruments are inserted—instruments so delicate that stray electrical waves or gases leaking into the casing may throw them off.

For that reason, the tubing is supplied in the "as drawn" condition, with a smooth surface that has a high radiation factor. Stainless is specified because plated material used in the past flaked off and short-circuited the instruments. The thin wall size (2.098" x .018" wall) is important; first, because of weight and, second, because of the close fit demanded. After the instruments are inserted, the tubing—closed by spinning—goes into an outer housing which must withstand pressures of 20,000 psi.

Whatever you want tubing for—an instrument housing, hypodermic needle, radio antenna, or heat exchanger—you'll find that the high quality of Superior tubing saves you time, money and production headaches. Send for your free copy of Bulletin 40—*A Guide to the Selection and Application of Superior Tubing*. SUPERIOR TUBE COMPANY, 2008 Germantown Ave., Norristown, Pa. *On the West Coast:* Pacific Tube Co., 2008 Smithway St., Los Angeles 22, Calif.



PRE-TESTING an assembly before it is inserted into the Superior tube.

Superior Tube

The big name in small tubing

All analyses .010" to ½" OD
Certain analyses in light walls up to 2¼" OD



SKILLED HANDS EXPEDITE ORDERS . . . AT UDDEHOLM

Here is a typical example:

TOOL STEEL—ONE GRADE—36 SIZES

The minute the Telephone Salesman picked up the phone, he knew he had a tough rush-order on his hands. The customer wanted 36 sizes of UHB 46 OIL-HARDENING ANNEALED TOOL STEEL from stock! Quickly checking his stock list, he gave the buyer the standard Uddeholm answer: "Can do . . ."

ALMOST FOUR TONS

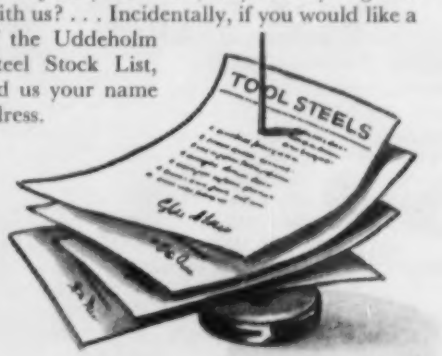
When the Warehouse Foreman got the order from the front office, he added up the weight . . . 7588 pounds . . . with sizes ranging from ¼" square through 6" round to 2" x 12".

ONE-DAY DELIVERY

Noting that the Foreman had marked the order "PRIORITY", the Warehousemen quickly located the items and marked them for immediate shipment. Twenty-four hours from the time the order was entered, the delivery truck rolled up to the customer's unloading platform!

SERVICE

Uddeholm warehouses are service-minded. No matter how large or how small the order, it receives immediate attention. We feel that it is our duty to meet delivery dates. The next time you are in the market for quality tool steel, why don't you get in touch with us? . . . Incidentally, if you would like a copy of the Uddeholm Tool Steel Stock List, just send us your name and address.



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UDDEHOLM COMPANY OF AMERICA, INC.

Tool and Die Steels
Specialty Strip Steels

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THE FIRST AND ONLY UNIT WITH *COMPLETE AUTOMATION* FOR THE HEAT TREATING INDUSTRY

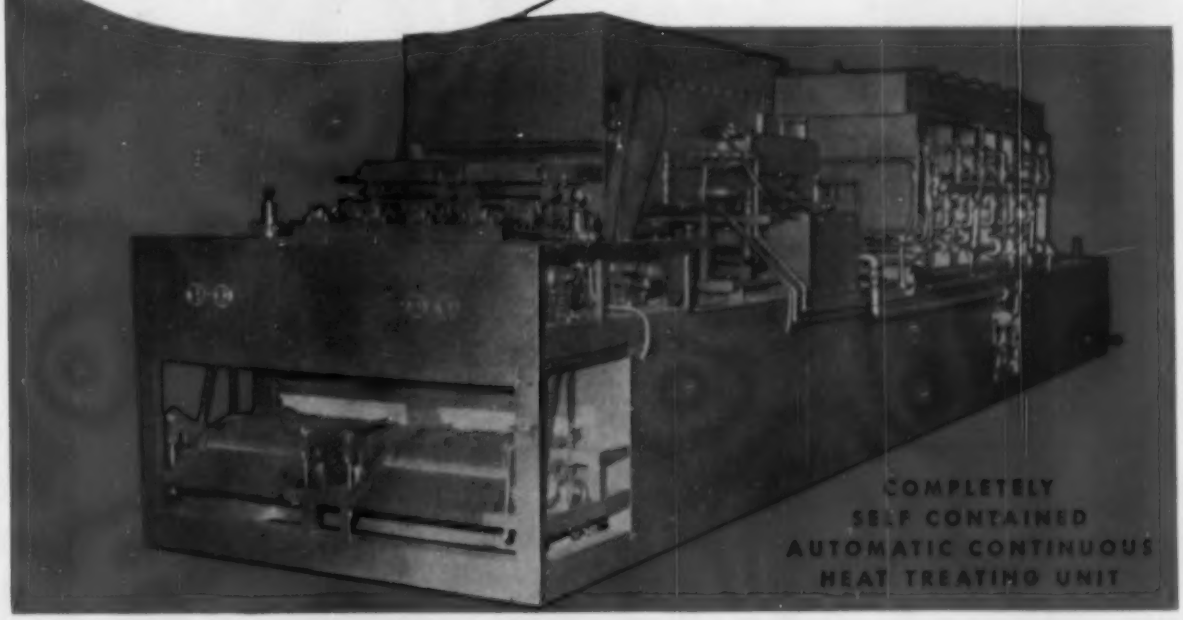
FITS IN YOUR *AUTOMATIC PRODUCTION* LINE LIKE A MACHINE TOOL OR CAN BE A PART OF YOUR *HEAT TREATING DEPARTMENT*

No Detours or Handling — six successive continuous operations. Automatic loading — Pre wash, rinse and dry — Harden — Oil quench — Wash, rinse and dry — Temper, plus other salt or water operations desired.

One or more independent, separately controlled conveyors throughout the line for simultaneous processing different parts without mixing.

And, the Unitline occupies only one third the space heretofore required for such operations.

See the Unitline. It will save you time, money, floor space, and do a better job.



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Industrial Heat Treating Equipment

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ACME *Automatics* DELIVER

HIGH OUTPUT AT LOW COST ON PRODUCTION FINISHING

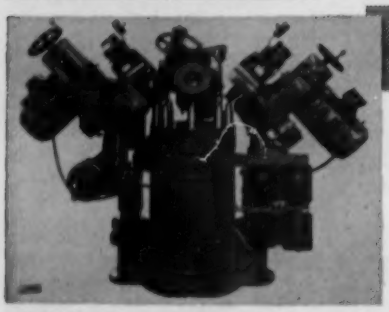


ACME *Semi-Automatics*



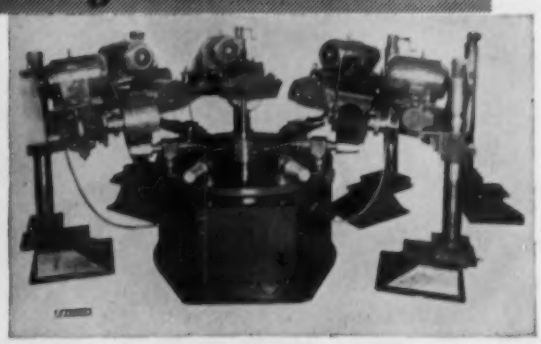
Acme Semi-Automatic Polishing and Buffing Machines are available in a wide range of types and spindle arrangements.
LEFT—Acme Type B-10, single spindle.
RIGHT—Acme Type L4, four spindle, an automatic indexing machine.
Acme "Semi's" meet production and finish demands on a great variety of parts. Their efficiency and dependability has been fully demonstrated in industry.

CATALOG ON REQUEST



ACME *Rotary Automatics*

Acme Rotary Automatics are furnished with Indexing and Continuous table operation. They are available with table sizes from 18 inches to 24 feet diameter and are outstanding production machines.

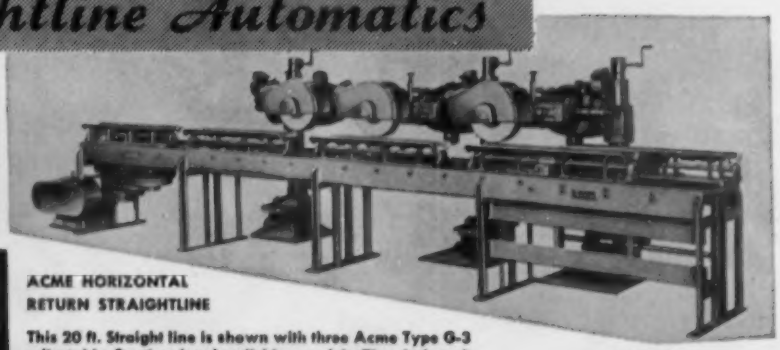


ABOVE—Acme Type L-8-L Rotary with variable speed control with less than one second index interval. Unusually efficient for finishing small parts.
RIGHT—Acme 66 inch, 7 station indexing rotary with right angle attachment illustrating one of many efficient Acme arrangements of these versatile units.

CATALOG ON REQUEST

ACME *Straightline Automatics*

Acme Straightline Automatics standardize polishing and buffing operations at high production levels at low unit costs. Available in horizontal return over and under, loose fixture and other types and from 20 to 80 feet in length. Many effective arrangements to meet specific requirements.



ACME HORIZONTAL RETURN STRAIGHTLINE

This 20 ft. Straight line is shown with three Acme Type G-3 adjustable floating head polishing and buffing lathes. It can be increased in length to 80 ft. by adding standard 10 ft. sections.

CATALOG ON REQUEST

RECOMMENDATIONS AND QUOTATIONS

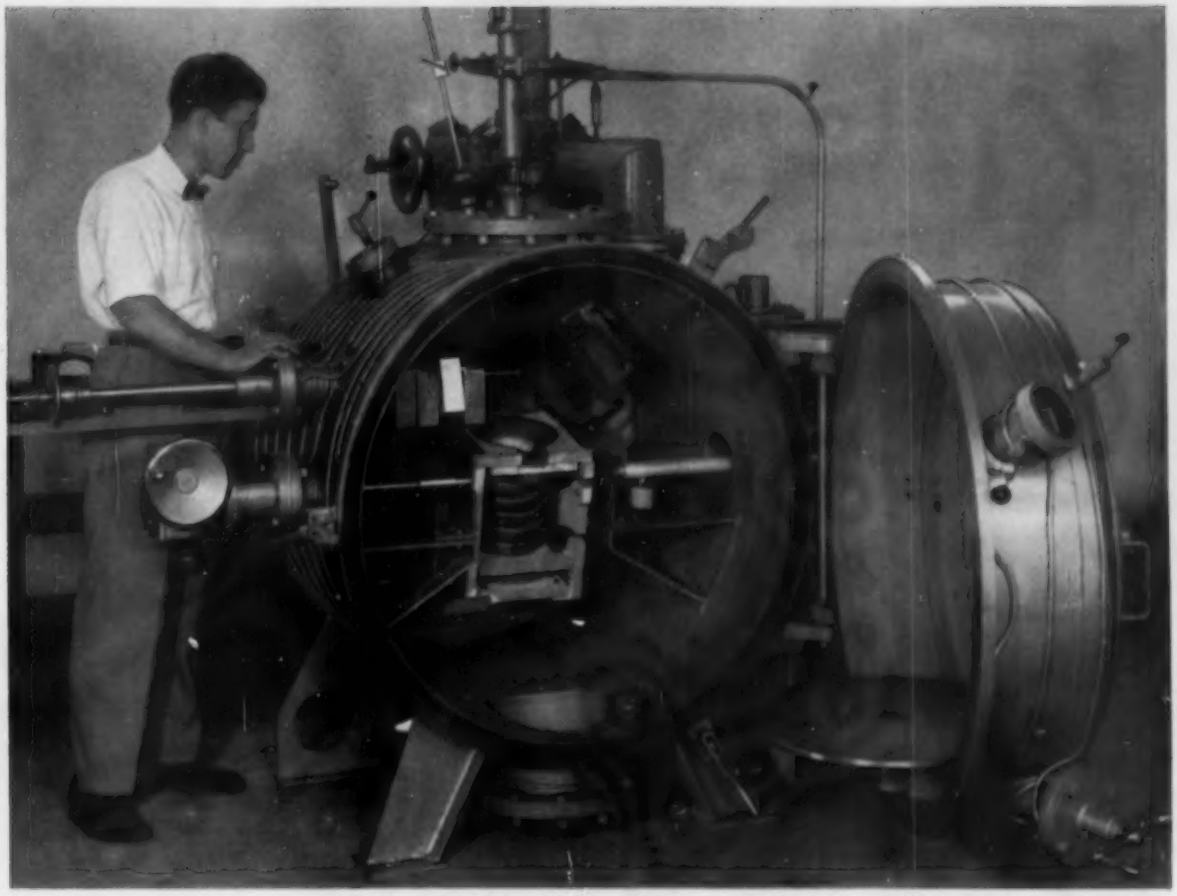
Please send blue prints or finished and unfinished samples of part to be finished with detailed information on present finishing operation and production requirements. Recommendations and quotations will be furnished.

SPECIAL MACHINERY — AUTOMATIC BUFFING MACHINES

ACME *Manufacturing Co.*

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Builders OF AUTOMATIC POLISHING AND BUFFING MACHINES FOR NEARLY HALF A CENTURY



Featured at the 1955 National Metal Exposition, this new NRC Model 2555 fifty pound vacuum induction furnace provides ease of operation, ingenious charging and alloy addition devices, rotary mold table. It is already in use by aircraft companies, engine manufacturers, investment casters, specialty steel producers.

Develop Your OWN Vacuum Melted "Ultra Alloys" in this NRC Vacuum Furnace

Alert metallurgists today know about the greater impact, fatigue, and high temperature strength, the improved machinability, the superior cleanliness of the new "ultra alloys" emerging from vacuum furnaces. Start your program now for evaluating these materials and adapting them to your requirements.

A vacuum furnace of your own provides the most efficient means of creating the wide range of alloys you will want to develop and test for your own purposes.

Especially designed for development programs, the standard NRC Model 2555 is unmatched for dependability, flexibility, and convenience. This is the natural result of the experience gained in building and operating more high vacuum furnaces than anyone else in the world.

See the new Model 2555 at the National Metal Exposition, Philadelphia Oct. 17 — Oct. 21 Booth 1577

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Please send me Model 2555 Data Sheet ☐ NRC Vacuum Furnace Bulletin ☐
Have your representative call ☐

Name.....Title.....
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Advanced know-how makes the difference

Hitting the target is the result of know-how based on experience and experiment . . . of knowledge, imagination, skill and an intangible spirit that seeks perfection. Here are the highlights of casting methods which show how advanced know-how at Cooper Alloy has made it possible to produce intricate stainless steel parts to quality standards formely considered impossible.

SHELLCAST®

The production of cast shapes in thin, light weight, resin-bonded shells was born of the necessity to produce molds faster, more economically and with greater accuracy . . . and to cast parts to closer tolerances, with superior surface finish, greater legibility of markings and better appearance, as well as with thinner sections, small cored holes, well detailed contours, minimum draft and intricate recesses. These advantages are available to design engineers and manufacturers who specify—"Shell-cast by Cooper Alloy" —for their stainless steel components.

SHELLCORE

When the interior surface of the casting is as critical as the exterior, the core becomes a problem. The answer lies in the production of hollow "Shell" cores of superior accuracy and fine detail, which fit the mating molds much more closely than sand cores ever could. For extremes of tolerances—inside and out—Cooper Alloy *advanced know-how* with shell molds and shell cores makes the difference.

COREMOLD

Where specifications demand extreme smoothness of surface and close matching of many components, the use of special core mold assemblies becomes necessary. Core sand is used for making molds which provide excellent mating surfaces for cores and assure extra smoothness to the casting surface. Cooper Alloy *advanced know-how* puts coremold methods at your disposal.

CENTRIFUGAL CASTING

Casting centrifugally offers many specific advantages, including the ability to cast very thin, light weight airfoil sections. Whether made in metal molds or in sand, castings by the centrifugal method meet highest quality standards, particularly when backed up with Cooper Alloy *advanced know-how.*

SAND CASTING

The heart of the foundry industry still lies with quality sand castings. But so important is the engineering, the patternmaking, the heading and gating, melting, molding, pouring, heat treatment, pickling . . . so critical is the use and application of x-ray, zyglo, gamma ray, pressure testing . . . so variable are the control items envolved in pouring thirty different high alloys . . . that even in the production of castings by "conventional methods" quality depends on experience. Here too, Cooper Alloy *advanced know-how* makes the difference.

Tomorrow is ever with us . . .

Our search for better ways to produce quality stainless steel castings more economically . . . goes on continually. Research links us with tomorrow and assures you of the best in thinking, the best in technology. Cooper Alloy *advanced know-how* can make the big difference in your product. Your inquiries are invited.

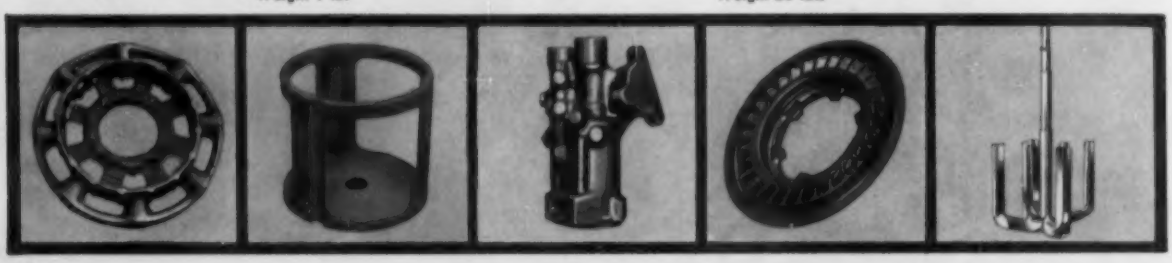
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produced by Shellcast.®
Weight 35 lbs.

INSTRUMENT HOUSING
produced by combining Shellcast® and shellcore.
Weight 1 lb.

JET AFTERBURNER COMPONENT
produced by coremold.
Weight 11 lbs.

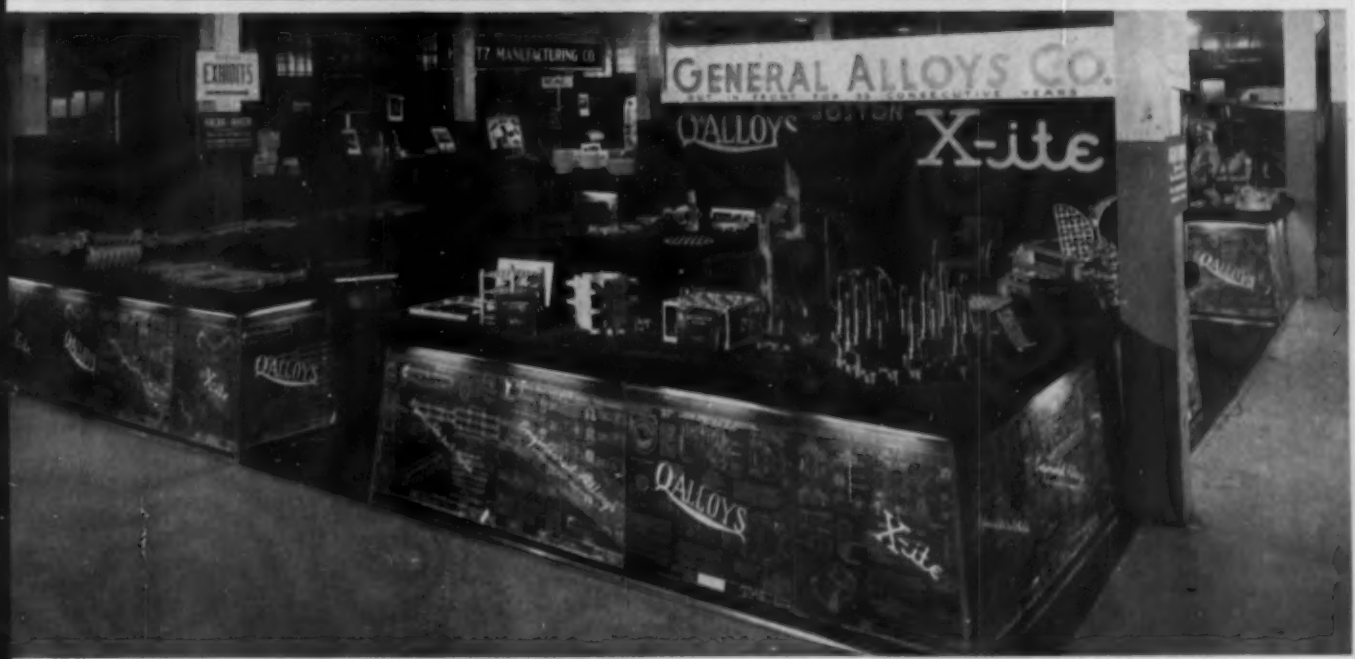
SUPERCHARGER DIAPHRAGM
produced by centrifugal casting using coremolds.
Weight 25 lbs.

CHEMICAL AGITATOR
produced by sand casting.
Weight 2500 lbs.



COOPER ALLOY
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Foundry Products Division

THE FOOTSTEPS OF GENERAL ALLOYS MARK THE PATH OF AN INDUSTRY



1 . . 5 . . 10 . . 15 . . 20 . . 25 . . 30 . . 35 . . 37

YES, 37 CONSECUTIVE YEARS

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THERE IS NO SUBSTITUTE FOR EXPERIENCE

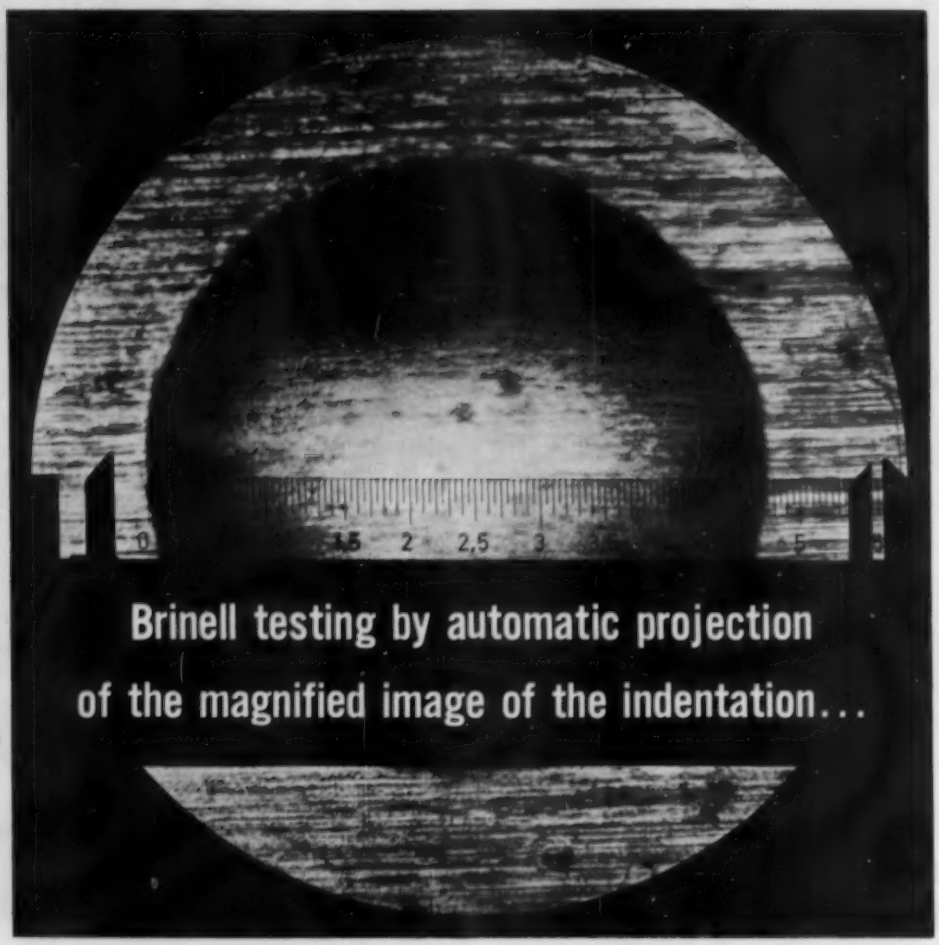
General Alloys Company is an engineering organization with 37 years experience in the design and manufacture of heat resistant and stainless steel castings. The design of high temperature tooling is our specialty. Consult our specially trained sales engineers in Booth No. 204 at the National Metal Show concerning your alloy problems.

GENERAL ALLOYS COMPANY, BOSTON, MASS.

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Q'ALLOYS THE QUALITY NAMES IN ALLOY FOR HEAT CORROSION ABRASION X-ite

A typical full-size image as seen on the screen of our REFLEX Hardness Testing Machine—3000 kg capacity, 10mm ball, motorized; rate of magnification applied: 20 x.



NO microscope.. NO eye fatigue with the GRIES REFLEX HARDNESS TESTING MACHINE

using the Carl Zeiss optical system



For the first time, routine production Brinell tests are possible, with the results shown directly in diameters of ball indentations, in accordance with the standard Brinell method. Simple limit stops show the operator in *one look* whether the material comes up to specifications or not.

Using the Carl Zeiss optical system, the rate of magnification can be varied to 20x, 70x, or 140x. Thus, small balls and small loads may be applied advantageously, in many cases. For instance, a 187½ kg load on the 2½ mm ball gives exactly the same result in *standard* Brinell units as 3000 kg load on the 10 mm ball. When magnified 70 times, the images of indentations by the 2½ mm ball permit very precise tests.

Thus the GRIES REFLEX system, with its automatic projection, speeds up tests and permits more precise test results. It is the most modern means of hardness testing—for Brinell, Vickers, Knoop or Grodzinski tests.

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Booth No. 240

Write for free copy of Bulletin A-14.

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Testing Machines Division • New Rochelle 3, N. Y.

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. . . it will make money for you

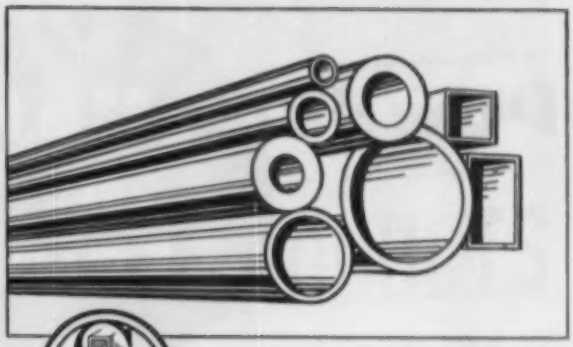
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GREENVILLE, PA.



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Stainless and Nickel Alloy
. . . Seamless and Welded

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Pipe and other Pressure Tubes
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Heat Exchanger Tubes
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All *cold drawn* and *bright* annealed except special heating element tubes which are as welded and bright annealed.

Large stocks of raw material assure early shipping schedules.

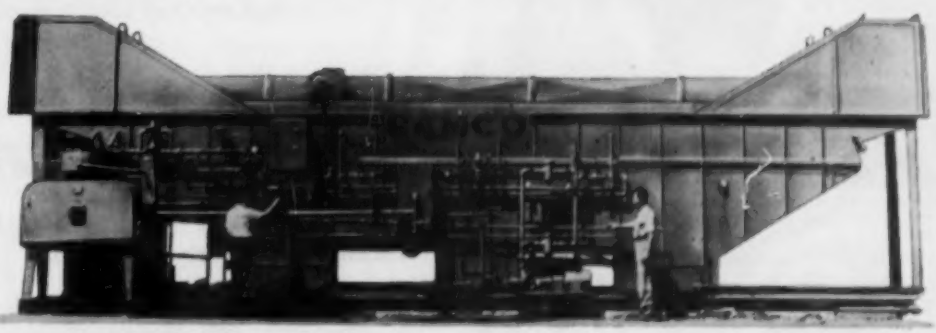
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CONVENTION—PHILADELPHIA, OCTOBER 17-21, 1955

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1. **"General Metallurgical Problems in the Design of Nuclear Power Reactors"**
   Vincent P. Calkins
   Aircraft Nuclear Propulsion Project
   General Electric Co.

2. **"Preparation of Metal Powders for Nuclear Reactor Purposes"**
   Premo Chiotti and Harley A. Wilhelm
   Institute for Atomic Research
   Iowa State College

3. **"The Latest Developments in the Theory of Sintering"**
   Leslie L. Seigle, Head
   Fundamental Metallurgy Section
   Sylvania Electric Products, Inc.

4. **"The Powder Metallurgy of Beryllium and Zirconium"**
   Harold Hirsch
   Knolls Atomic Power Laboratory
   General Electric Co.

5. **"Alloy Formation by Powder Metallurgy"**
   Henry A. Saller and Frank A. Rough
   Battelle Memorial Institute

6. **"New Methods of Powder Metallurgy for Nuclear Reactor Purposes"**
   William D. Manly
   Oak Ridge National Laboratory

7. **"Safe Handling of Pyrophoric and Radioactive Materials"**
   L. R. Kelman, A.B. Shuck and R. C. Goertz
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Bonderites with Built-In Crystal Refining Agent

Series 800 Bonderites contain ICRA (Internal Crystal Refining Agent). Built-in control means finer, denser, more uniform crystalline structure, improved paint adhesion, luster and reflectivity.

See these new Bonderite coatings. Talk over possible applications to your requirements with one of the Parker technical men.



Enameling iron angle on left, finished in conventional 2-coat porcelain enamel, failed when twisted 70°, less than the metal's elastic limit. Finish coat only, over Parker Pre-Namel 410, on angle at right, withstood 240° twist before failing.

See the exciting new Parker Products at the Metal show, Booth 1549, Philadelphia, Oct. 17-21.

1915 40th year 1955

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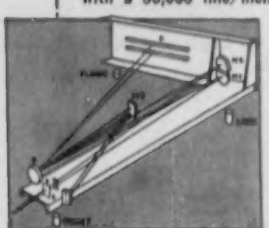
The speed, precision and versatility you want in a direct reader are now yours in the Atomcounter. Everywhere you look you see evidence of ingenious engineering — a dispersing system entirely new in concept; a versatile, reliable excitation unit; simplified electronic circuitry. For routine analyses of alloy steels the Atomcounter offers you *exclusive* advantages:

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For more information on the ways the JAco Atomcounter can help you, write today for Bulletin DR.

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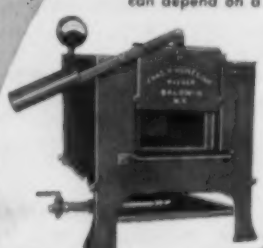
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From Vacuum Melting—improved alloys with exceptional properties

...longer FATIGUE LIFE, for example

Vacuum-melted alloy steels mean new standards of performance in parts subjected to cyclic stressing. For vacuum-melted metals exhibit *exceptional* fatigue properties—even when heat-treated to near maximum limits.

For example, springs . . . bolts . . . bearings . . . motor and machinery parts of vacuum-melted alloys – even jet engine turbine blades operating under tremendous stress – far outperform those of conventional air-melted metals.

That's because high-vacuum melting literally sucks gaseous impurities and inclusions from the molten metal . . . eliminates focal points that cause fatigue cracking. What's more, vacuum-melted metals give you higher creep and stress rupture strength . . . better ductility . . . improved fabrication characteristics.

Now you can take advantage of the unique properties of vacuum-melted metals for your applications. For Vacuum Metals Corporation, pioneer in development and leading producer of vacuum-melted alloys, has them available in tool, high-speed, stainless and alloy steels as well as special ferrous and nonferrous alloys. For help with metal problems you believe vacuum-melted metals might solve, please write in as much detail as possible to *Vacuum Metals Corporation, P. O. Box 977, Syracuse 1, N. Y.*

VMC

VACUUM METALS CORPORATION

Jointly owned by Crucible Steel Company of America and National Research Corporation

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2 How can I find a brass cleaner that gives better protection against tarnishing?

3 How can I reduce rejects due to faulty electrocleaning of zinc die castings?

***Answer* 1** Following an Oakite recommendation, one plater made a small change in his steel-cleaning cycle and soon had two tankfuls of cleaning solution doing the work of three—and the plate adhesion was improved. *See booklet offered below.*

***Answer* 2** Oakite has a new brass cleaner that provides scientific protection against the oxygen that tarnishes brass and other copper alloys during the application of reverse current. *See booklet offered below.*

***Answer* 3** Oakite has an anodic conditioner that offers brighter plating of zinc die castings . . . with no anodic blackening and fewer rejects. *See booklet offered below.*

FREE For more information about the electrocleaning of steel, brass or zinc die castings, send for one or all of the booklets listed in the coupon.



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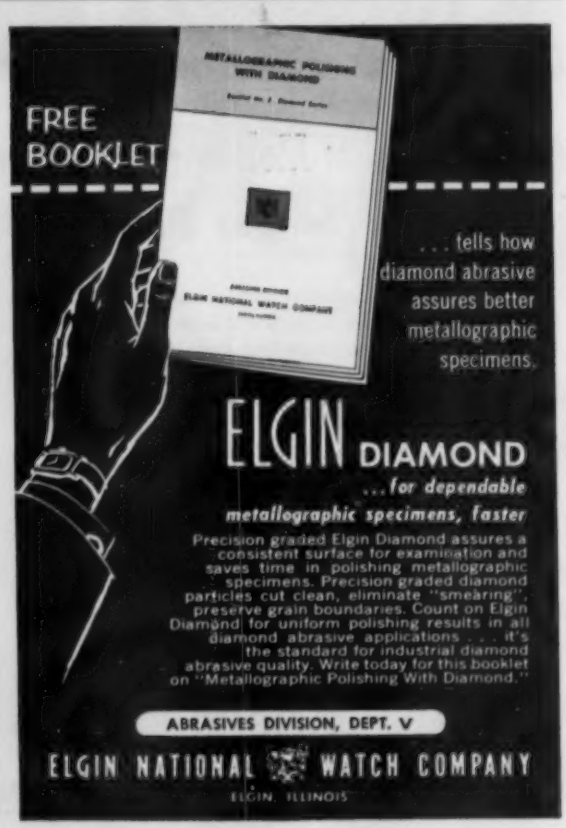
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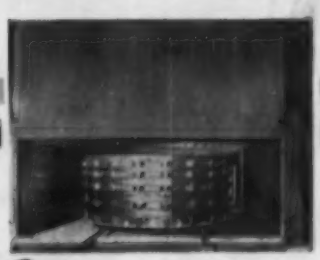
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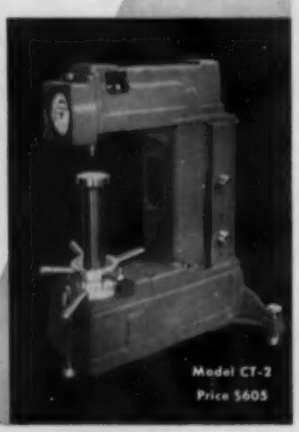
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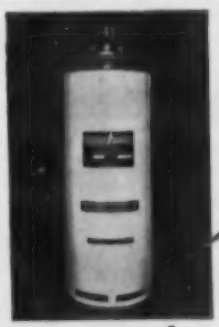
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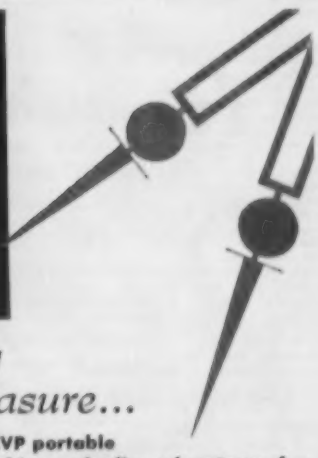
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• Index to Advertisers •

Acheson Colloids Co. ..... Back Cover
Acme Manufacturing Co. 278
Ajax Electrothermic Corp. 64
Aldridge Industrial Oils, Inc. 55
Allegheny Ludlum Steel Corp. 33
Allied Research Products, Inc. 188
Alloy Engineering & Casting Co. 6
Alloy Metal Wire Div.
H. K. Porter Company, Inc. 180
Almco Div. 52
Alpha Corp. 53
Alvey-Ferguson Co. 23
American Brass Co. 65
American Cast Iron Pipe Co. 57
American Chemical Paint Co. 271
American Cyanamid Co.
Metal Chemicals Section 104C
American Electro Metal Corp. 222
American Gas Furnace Co. 7
American Machine & Metals, Inc. 8
American Platinum Works 151
American Roller Die Corp. 53
American Smelting & Refining Co. 238, 239
American Society for Metals 38, 284, 290
Ampco Metal, Inc. 223
Amplex Div., Chrysler Corp. 10
Apotheosaries Hall Co. 286
Armour & Co., Ammonia Div. 67
Armstrong-Blum Mfg. Co. 226
Arwood Precision Casting Corp. 189
Ashworth Brothers, Inc. 246

Babcock & Wilcox, Tubular Products Div. ... 32
Baker & Adamson Products General Chemical Div., Allied Chemical & Dye Corp. ... 213
Baldwin-Lima-Hamilton 249
Barber-Colman Co. 49
Barber-Colman Co. Wheeler Instruments Div. 332B
Bausch & Lomb Optical Co. 104D
Bell & Gossett Co. 366
Bellis Co. 55
Beryllium Corp. 268
Bethlehem Steel Co. 187
Branson Instruments, Inc. 50
Bristol Co. 193
Brooks & Perkins, Inc. 242
Buehler, Ltd. 184D

Cambridge Wire Cloth Co. 142
Carborundum Co. 237, 255
Carl Mayer Corp. 288
Carlson Co., G. O. 157
Carpenter Steel Co. 273
Casalbi Co. 332
Central Foundry Division
General Motors Corporation 34-35
Chace Co., W. M. 174
Chainveyor Corp. 338
Chase Brass & Copper Co. 311
Chemical Corp. 236
Cincinnati Milling Machine Co. 361
Cincinnati Sub-Zero Products Co. 224
Cities Service Oil Co. 195
Clark Instrument Co. 230
Climax Molybdenum Corp. 15
Columbia Tool Steel Co. 298
Continental Foundry & Machine Co. 26
Continental Industrial Engineers, Inc. 198
Cooley Electric Mfg. Co. 244
Cooper Alloy Corp. 280
Copperweld Steel Co. 4
Copperweld Steel Co., Ohio Seamless Tube Div. 30
Crucible Steel Co. of America 153, 177, 235

Darwin & Milner, Inc. 184
Detroit Electric Furnace Div., Kuhlman Electric Co. 218
Detroit Testing Machine Co. 50
Dies Co., J. W. 50
Diesel Power, Inc. 283
Dixon Corp. 62
Dow Chemical Co. 273
Dow Furnace Co. 309
Drever Co. 333
Du-Lite Chemical Corp. 31
duPont de Nemours & Co., Inc. 149, 251
Duraloy Co. 150

Easton Metal Powder 336
Eclipse Fuel Engineering Co. 192
Electric-Arc, Inc. 246
Electric Furnace Co. ..... Inside Back Cover
Electro Alloys Div., American Brake Shoe Co. 2
Electro Metallurgical Co., Unit of Union Carbide & Carbon Corp. 137
Elgin National Watch Co. 288
Engineered Precision Casting Co. 54, 176
Ercono Corp. 289
Erico Products, Inc. 54
Erie Foundry Co. 207
Ethyl Corp. 257

Fahralloy Co. 231
Ferguson Equipment Corp. 277
Finkl & Sons Co., A. 17
Firth Sterling, Inc. 205
Flinn & Dreffein Engineering Co. 240
Foxboro Co. 247

Garden City Fan Co. 53
Gas Machinery Co. 56
General Alloys Co. 281
General Electric Co. 47
Gordon Co., Claud S. 14
Great Lakes Carbon Corp. 309
Great Lakes Steel Corp. 231
Grieo Industries, Inc. 282
Grieo Reproducer Corp. 53

Handy & Harman 185
Hanson-Van Winkle-Munning 263
Harper Electric Furnaces Corp. 168
Harshaw Scientific Div., Harshaw Chemical Co. 254
Hayes, Inc., C. I. 36-37
Haynes Stellite Co., Unit of Union Carbide & Carbon Corp. 44
Heathath Corp. 181
Hevi Duty Electric Co. 182, 183
High Voltage Engineering Corp. 241
Holcroft & Co. 32A
Holden Co., A. F. 56
Homes, Inc., Chas. A. 286
Hooker Electrochemical Co. 46
Hoover Co. 54
Houghton & Co., E. F. 252-253

Illinois Testing Labs., Inc. 225
Industrial Heating Equipment Co. 186
International Nickel Co. 104A, 259
Ipsen Industries, Inc. 38-39
Ivy Company 291

Jarrell-Ash Co. 286
Jelliff Mfg. Corp., C. O. 51
Jessop Steel Co. 216A
Johns-Manville 164, 199
Jones & Laughlin Steel Corp. 139, 191

Kelite Corporation 248
Kemp Manufacturing Co. 147
Kennametal, Inc. 178
Kinney Mfg. Div. of N. Y. Air Brake Co. 11
Koppers Co., Inc. Engineering & Construction Div. 269

Kux Machine Co. 258
LaSalle Steel Co. 173
Latrobe Steel Co. 201
Leeds & Northrup Co. 264
Lepel High Frequency Labs. 216B
Lester-Phoenix, Inc. 152B
Lindberg Industrial Corp. 302-303
Linde Air Products Co., Unit of Union Carbide & Carbon Corp. 170, 250
Lithium Corp. of America 215
Little Falls Alloys, Inc. 53
Lord Chemical Co. 194
Lucifer Furnaces, Inc. 55

Magnethermic Corp. 245
Magnetic Analysis Corp. 49
Mahon Co., R. C. 59
Malayan Tin Bureau 62
Mallory-Sharon Titanium Corp. 16
Manhattan Rubber Div., Raybestos-Manhattan, Inc. 52
Maurath, Inc. 54
Merrill Bros. 138
Metal & Thermit Corp. 274
Metal Carbides Corp. 270
Metal Treating Institute 48
Midvale Co. 161
Minneapolis-Honeywell Regulator Co. (Industrial Division) 40-41
Mitchell-Bradford Chemical Co. 220
Mixing Equipment Co., Inc. 146
Molybdenum Corp. 260
Morehouse Machine Co. 27
Murray Way Corp. 243

National Metal Abrasive Co. 156
National Research Corp. 279
National-U.S. Radiator Corp., Plastic Metals Division 210
Niagara Alkali Co. 262
Niagara Blower Co. 158
Nitrogen Division Allied Chemical & Dye Corp. 306
North American Mfg. Co. 217
Northwood Chemical Co. 229
Norton Co. 18, 30

Oakite Products, Inc. 288
Ohio Crankshaft Co. 227
Ohio Seamless Tube Division of Copperweld Steel Co. 30
Olsen Testing Machine Co., Tinius 63

Pangborn Corp. 12, 145
Park Chemical Co. 159
Parker Rust Proof Co. 285
Penn Precision Products, Inc. 55
Pereny Equipment Co. 291
Pittsburgh Lectrodryer Corp. 300B
Plume & Atwood Mfg. Co. 13
Precoat Steel Co. 232
Production Specialties, Inc. 50
Pyrofax Gas Corp., A Unit of Union Carbide & Carbon Corp. 172
Pyrometer Instrument Co. 19
Pyrotl, Inc. 289

Radio Corp. of America 214
Randall Mfg. Co. 30, 283
Raybestos-Manhattan, Inc., Manhattan Rubber Div. 52
Reed-Prentice Corp. 167
Revere Copper & Brass, Inc. 141, 169
Riverside Metal Co., Div. of H. K. Porter Company, Inc. 166
Rockwell Co., W. S. 160
Rolled Alloys, Inc. 29
Roll Formed Products Co. 50
Rolock, Inc. 162
Rotary Electric Steel Co. 171
Rubicon Co. 35
Ryerson & Son, Inc., Jos. T. 68

Salem-Brosius, Inc. ..... 16A, B, C, D
Salt Bath Institute 197
Sandvik Steel, Inc. 165
Sargeant & Wilbur, Inc. 230
Saunders & Co., Alexander 226
Seymour Mfg. Co. 24
Sharon Steel Corp. 155
Shenango-Penn Mold Co. 152
Sieburg Industries 49
Sinclair Refining Co. 45
Smith Tube Corp. 283
Solventol Chemical Products, Inc. 5
Somers Brass Co., Inc. 242
Southern States Iron Roofing Co. 12
South Florida Test Service 291
Spencer Turbine Co. 179
Standard Steel Treating Co. 56
Stanwood Corp. 55
Star Stainless Screw Co. 52
Steel City Testing Machines, Inc. 152A
Stokes Machine Co. 42-43
Struthers Wells Corp. 216
Sun Oil Co. 60-61
Superior Steel Corp. 200A
Superior Tube Co. 275
Surface Combustion Corp. ..... Inside Front Cover
Swift Industrial Chemical Co. 52

Taber Instrument Corp. 49
Technic, Inc. 50, 52
Thermo Electric Co., Inc. 154
Thompson Products, Inc. 190
Timken Roller Bearing Co. 32
Titanium Alloy Mfg. Div. National Lead Co. 267
Titan Metal Mfg. Co. 184A
Torsion Balance Co. 290
Torsion Balance Co., Kent Cliff Laboratories Div. 49
Triplett & Barton, Inc. 291
Turco Products, Inc. 196

Uddeholm Co. of America 276
Union Carbide & Carbon Corp. 44, 137, 170, 250
Uniteast Corp. 200
United Scientific Company 58
Upton Electric Furnace Co. 56
U. S. Industrial Chemicals Co. 31
United States Steel Corp. ..... 56A, B, C, D
United Wire & Supply Corp. 218
Utica Drop Forge & Tool Corp. 148

Vacuum Metals, Inc. 287
Vanadium Alloys Steel Co. 143
Vanadium Corp. 365

Watson-Stillman Co., Div. of H. K. Porter Co., Inc. 175
Wauksee Engineering Co. 234
Waukesha Foundry Co. 219
Westinghouse Electric Corp. 144
West Instrument Corp. 234
Weston Electrical Instrument Corp. 256
Wheeler Instruments Div., Barber Colman Co. 332B
Wheelock, Lovejoy & Co., Inc. 212
White Metal Rolling & Stamping Corp. 54
Wilson Mechanical Instruments Div., American Chain & Cable 304
Wiretex Mfg. Co. 51

Yoder Co. 66
Young Bros. 289
Youngstown Welding & Engineering Co. 51

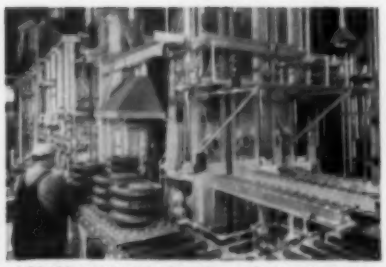
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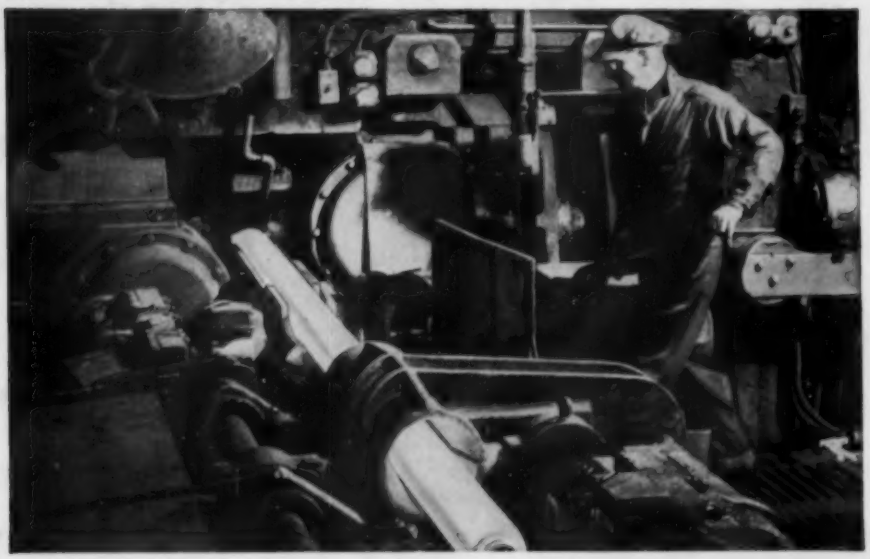
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